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Photo.-Mechl. Dept., Thomason College, Roorkee.

Photo by R. S. Pearson

Seasoning Experiment, Dandeli, North Division, Kanara, Bombay Presidency.

PREFACE

OWING to the nature of the enquiry, which involved carrying out seasoning tests with a variety of species, distributed all over India and Burma, it was not possible to restrict the experiment to one locality, while the duration of the experiment was fixed at three years. Under the circumstances it was found impossible to do more than exercise central control from the Forest Research Institute, to carry out the final inspection at the more important centres and to enlist the help of the Divisional Forest Officers in respect of all other work. It would have been quite impossible to carry out this detailed experiment had not the officers concerned taken a real personal interest in the work, and most loyally co-operated during all phases of its operation.

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Preliminary Note on the Seasoning of some Indian Timbers, by Natural Methods

by

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I. Introduction.

A considerable amount of information is available as to the methods of seasoning a few of the better known timbers of India, such as Teak, Sal, Deodar, etc., though little information is to hand in respect of the many valuable hardwoods, other than the above. It was therefore thought advisable to start an enquiry in 1914, with a view of ascertaining the best methods of dealing with certain important Indian hardwoods, and as a commencement 33 species were selected for testing. The results obtained have been of sufficient importance to justify an immediate extension of the enquiry on a much larger scale.

That we have little or no information as to how to season many of our timbers would in itself be a sufficient reason for such an enquiry, and if further justification is needed it is only necessary to state that many useful timbers found in the forests of British India either only command a very small market or are unsaleable.

There is yet another factor of equal, if not greater, importance than the above, *viz.*, that the more scientific and intensive working of our forests, a subject which is now receiving much attention from all Forest Officers, demands not merely the removal of mature trees of a few of the best species but also heavy fellings of all species. Such operations can only result in throwing enormous quantities of hardwood timbers on our hands to be marketed to the best advantage.

To introduce and create a market for such timbers, it is necessary to place them before the public in the best possible condition and this can only be done by proper conversion, followed by careful stacking and seasoning according to correct principles.

II. General Outline of the Enquiry.

The selection of species to be tested was based on proposals made by the Chief Conservators and Conservators of Forests of most of the Provinces and Circles in India and Burma. The scheme according to which the experiments were to be carried out was drawn up by the writer and his Assistant Mr. C. E. C. Cox, after having circularized all Forest Officers, Sawmill Managers and Timber Firms with a view to obtaining information as to the practical methods of seasoning at present in vogue.

From replies received it was apparent that no regular system for timber-seasoning was commonly pursued in India.

Appendix I is a copy of the original scheme, a *précis* of which is given below :—

(1) Seasoning of timber in the log, either (*a*) in the open or (*b*) in the shade, with either bark on or off, for varying periods, and subsequent conversion and seasoning of the sawn material, so as to bring the total seasoning period up to 36 months.

(2) Girdling trees, left standing for periods varying from 12 to 30 months, thereafter felling and conversion of the logs and further seasoning of the sawn material so as to bring the total seasoning period up to 36 months.

(3) Seasoning logs, immersed either in fresh water or in the mud of tidal creeks, followed by a further period of seasoning, after conversion, so as to bring the total seasoning period up to 36 months.

(4) Felling trees at different seasons of the year and subsequent seasoning in the log and after conversion in the form of planks.

(5) Conversion of green logs, the converted material being either placed in stacks to season under cover or immersed at once in water for a stated period previous to seasoning under cover.

(6) Seasoning timber in the log with bark on, and the ends of the logs treated with either Loracine, or Ligno, or Tar and cowdung, with subsequent conversion and seasoning for a total period of 36 months.

(7) Seasoning timber in the log with a saw-cut to the centre, with subsequent conversion and a further period of seasoning in the form of planks and scantlings.

(8) Study of the question of discolouration, cracking, warping, contraction, degree and rate of seasoning, insect attack and decay of timber treated under the above methods; and comparison of the relative degree of success attained under each method, with the corresponding results obtained by the method of treatment outlined in section (1) above.

The extended scope of the scheme together with the number of species to be tested necessitated sub-dividing the experiment into several sections and distributing the work amongst different Provinces. This system had the advantage of allowing the timber to be seasoned under varying climatic conditions.

The distribution was as follows :—

Province.	Division in which experiments were carried out.	Species tested.
Bengal.	Kurseong	*Albizzia procera.* *Anthocephalus Cadamba.* *Artocarpus Chaplasha.* *Cedrela Toona.* *Dillenia pentagyna.* *Duabanga sonneratioides.* *Lagerstrœmia parviflora.* *Michelia Champaca.* *Schima Wallichii.* *Terminalia belerica.*
	Chittagong.	*Artocarpus Chaplasha.* *Lagerstrœmia Flos-Reginæ.*
	Darjeeling.	*Machilus odoratissima.*
Bombay.	North Division, Kanara.	*Adina cordifolia.* *Bassia longifolia.* *Dalbergia latifolia.* *Grewia tiliæfolia.* *Lagerstrœmia microcarpa.* *Ougeinia dalbergioides.* *Pterocarpus Marsupium.* *Terminalia paniculata* *Xylia xylocarpa.*
	West Division, Kanara.	*Adina cordifolia.* *Lagerstrœmia microcarpa.* *Terminalia paniculata.* *Xylia xylocarpa.*

Province.	Division in which experiments were carried out.	Species tested.
United Provinces.	Lansdowne. Bahraich. Ramnagar and Siwaliks. Ramnagar. Haldwani. Jhansi. Kheri.	*Albizzia odoratissima.* *Bassia latifolia.* *Bombax malabaricum.* *Dalbergia Sissoo.* *Shorea robusta.* *Terminalia Arjuna.* ,, *tomentosa.*
Punjab.	Lahore. Rawalpindi and Kangra.	*Morus indica.* *Dalbergia Sissoo* *Pinus longifolia.*
Central Provinces	South Chanda.	*Adina cordifolia.* *Diospyros Malanoxylon.* *Lagerstrœmia parviflora.* *Ougeinia dalbergioides.* *Pterocarpus Marsupium.* *Stephegyne parvifolia.* *Tectona grandis.* *Terminalia Arjuna.* ,, *tomentosa.*
Bihar and Orissa	Singhbhum. Sambalpur.	*Shorea robusta.* *Pterocarpus Marsupium.*

The scheme as originally laid down was adhered to with a few minor modifications, such as small extensions to the N. Kanara experiments, by which yet another method of seasoning was added, and slight alterations as to dates of felling and conversion to meet local conditions in the various Provinces.

III. Method adopted in checking Experiments and data on which results are based.

The results are based on tests carried out with 33 species comprising 1,004 logs, converted into 10,004 planks, scantlings and sleepers.

Appendix II illustrates the forms maintained to record the progress of each experiment, and Appendix III is the form in which results of interim and final inspections were recorded.

The method followed at the final inspection of each species of timber was to carefully inspect each individual plank or scantling, to record in the form given as Appendix III all defects, if any, and after having gone over all the timber pertaining to one batch, to pass a general note on its condition, and finally to record the relative value of each batch to the whole. Later, after the experiments were completed in every Province, computations were made of the percentage of timber recorded as sound, badly cracked, badly warped and insect-attacked, of each species seasoned according to different methods, the information concerning which is given in Appendix IV. It was found that, without exception, the remarks passed in the general notes in the field as to the state of the timber were fully corroborated by the percentage figures worked out later at Dehra Dun, which clearly indicate that the method adopted for recording the experiments fully met the conditions of the case.

It was necessary to ascertain whether timber of any individual log cracked before or after the log was converted; to do so sketches of the ends of all logs were taken, directly after felling the tree and again before conversion: this, though a somewhat tedious process, met the case and was of the greatest value during the final inspection.

It was of great importance to ascertain the degree of seasoning at the time of the final inspection and, in some cases, during the progress of the experiment. In order to do so, samples of the timber were submitted to the Chemical Adviser for analysis. In this connection very definite factors were established as to the rate and degree of seasoning in different localities. By referring to Appendix IV it will be seen that the timber during December to January, in a fairly dry locality such as Allapilli, in the Central Provinces, after three years' seasoning, in a shed, contained somewhere about 16 per cent. of moisture; in the very dry zone of the Punjab, at Changa Manga, timber seasoned in the open, contained from 8 per cent. to 12 per cent. of moisture; while in the wet zone in Bengal, at Sukna in the Kurseong Divison, the average moisture was near 25 per cent. and, in some cases, as high as 44 per cent. and this after three years' seasoning.

IV. Results obtained.

(*i*) GENERAL REMARKS.

At the time the experiments were initiated some doubt existed as to whether sufficiently definite results would be obtained to justify conclusions being drawn as to the correct methods of seasoning the different species of timber. In the majority of cases, however, excellent results have been obtained: a glance at the records given in Appendix IV, against such species as *Bombax malabaricum, Duabanga sonneratioides, Dillenia pentagyna, Diospyros Melanoxylon, Lagerstrœmia Flos-Reginæ, Terminalia belerica* and many others will fully support this assertion. In the case of such timbers as *Dalbergia Sissoo* and *Dalbergia latifolia*, both timbers of excellent quality, which rarely split seriously while seasoning, the difference in results obtained by seasoning the timber in various ways is not so marked. In the case of *Bassia latifolia, Grewia* *tiliæfolia* and *Xylia xylocarpa* (Indian) very satisfactory results were not obtained, when seasoning according to the methods adopted, though some methods gave distinctly better results than others, while in the case of *Anthocephalus Cadamba* the results were negative in every instance.

The results show that the number of species which should be either girdled, or the timber converted from green logs, with or without subsequent immersion in water, is about equal, and that about 94 per cent. of the total number of species tested must be treated either according to one or other of these two methods. Natural seasoning in the log, with or without bark on, in the shade or in the open, and with or without ends treated with a coating of any protective substance, has only given beneficial results with high quality timbers, such as *Dalbergia latifolia*, *Ougeinia dalbergioides*, the *Albizzia* spp., etc.

The experiments throughout indicate the great importance of careful stacking of timber, on level ground, with free circulation of air round each piece. Without wishing in any way to labour this point, it may be said that satisfactory results cannot be obtained without proper attention being paid to this work. It is also advisable to break the stacks and turn the timber, if left for more than 3 or 4 months in one place, this being especially necessary in damp climates. In some of the experiments, as for instance those carried out at Sukna in Kurseong and at Dandeli in the North Division, Kanara, the timber after conversion was stacked in the open, under the shade of trees, both places having a heavy rainfall. This resulted in the timber of certain species being heavily attacked by fungus and in all cases resulted in undesirable discolouration of the timber. At Allapilli in the South Chanda Division, the timber was stored in a suitable shed, with very beneficial results, which fully justified the extra cost. Though permanent seasoning sheds, entailing a somewhat heavy initial expenditure, are no doubt justified in certain cases, it is quite feasible to erect quite temporary shelters in other cases, the cost of which will be more than repaid by the higher prices realised for the timber.

(*ii*) RESULTS ACCORDING TO SPECIES.

(1) **Adina cordifolia** (Appendix IV-1).

(*a*) *Locality where tested.*—North and West Divisions, Kanara, Bombay ; and South Chanda, Central Provinces.

(*b*) *Best methods of seasoning.*—Conversion from green logs and seasoning for 12 months under cover (Bombay), or girdling for 12 to 18 months followed by a further seasoning period of 6 months in the plank (Central Provinces).

(*c*) *Other methods of seasoning.*—The results of felling either in cold, or hot weather or in the rains gave very similar results. Attack by insects was heavy, especially when the logs were seasoned with bark on, while by removing the bark cracking was excessive. Treating the ends of logs with any composition did not materially retard cracking.

(*d*) *General remarks.*—This timber is more suitable for cutting up into planks, boards, and rafters than into beams.

NOTE.—Mr. Carr, D.F.O., South Chanda, made a subsequent inspection of the timber and noticed that all timber seasoned according to methods described under section (*c*) was further attacked by insects, whereas that seasoned according to methods advocated under section (*b*) showed no tendency to insect attack.

(2) **Albizzia odoratissima** (Appendix IV-2).

(*a*) *Locality where tested.*—Lansdowne Division, United Provinces.

(*b*) *Best method of seasoning.*—The best results were obtained by naturally seasoning the timber in the log, placed in the shade. It takes about 24 months in the log and 6 months in the plank to thoroughly season 2″ planks under cover.

(*c*) *Other methods of seasoning.*—First immersing the logs in water for 4 months, followed by 15 to 21 months seasoning on land and finally 8 to 13 months seasoning in the plank, gave results distinctly inferior to those obtained with natural seasoning on land, both in respect of splitting and colour of the timber.

(*d*) *General remarks.*—The timber is suitable for cutting into planks and rafters, and is a valuable ornamental wood.

(3) **Albizzia procera** (Appendix IV-3).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—Conversion from green logs, followed by 12 months' seasoning in the plank under cover.

(*c*) *Other methods of seasoning.*—The timber throughout was good. Results little inferior to those resulting from green conversion were obtained by either girdling the trees or by seasoning the timber in the log, with the ends either tarred, or smeared with Loracine or cowdung and mud. The sap-wood is useless and perishes rapidly by fungus and white-ant attack.

(*d*) *General remarks.*—The grain and colour of this timber was good, even after 3 years' exposure in a damp climate. It cuts up well into boards and can be used for both internal and external work. This timber is not in great demand in Bengal, but fully deserves further consideration.

(4) **Anthocephalus Cadamba** (Appendix IV-4).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—Not known, the timber resulting from all experiments was rotten, due to fungus attack. The timber, which was all seasoned in the open and exposed to three heavy monsoons, had chiefly deteriorated at the points of contact in the stacks. The timber which came from the bottom of the piles and which had therefore been partly protected, was found to be sound and hard, which indicates that were it to be seasoned under cover for about 12 months and the stacks broken occasionally, the timber would season without deteriorating. This supposition is partly corroborated by the fact that this timber is extensively used for tea-boxes, where it is not exposed to excessive moisture. From the nature of the timber it is not suitable for anything but internal match-boarding, light rafters, dry goods packing cases, and to a limited extent for joiner's work.

(5) **Artocarpus Chaplasha** (Appendix IV-5).

(*a*) *Locality where tested.*—Kurseong and Chittagong Divisions Bengal.

(*b*) *Best method of seasoning.*—The results obtained both in Kurseong and in Chittagong show that it is best to girdle the trees but that there is no advantage in allowing the trees to stand girdled for over 12 to 18 months. After felling and conversion, the planks and rafters should, if possible, be allowed to season for a further period of six months under cover.

(*c*) *Other methods of seasoning.*—Seasoning in the log either with bark off, or with bark on, and with the ends protected, as also green conversion, gave fair to good results though, in several cases, these methods of seasoning gave rise to fine surface and end cracks.

(*d*) *General remarks.*—The sap-wood of this timber perishes very rapidly and should be excluded when converting the logs into planks and rafters.

(6) **Bassia latifolia** (Appendix No. IV-6).

(*a*) *Locality where tested.*—Bahraich Division, United Provinces.

(*b*) *Best method of seasoning.*—The best results were obtained by converting green logs, followed by stacking in the shade for 12 to 18 months. Better results were obtained with one-inch than with two-inch planks, while in both there was a considerable amount of surface cracking ; the two-inch planks showed a strong tendency to warp.

(*c*) *Other methods of seasoning.*—Seasoning in the log gave poor results, but Mr. Clifford, who inspected this timber, is strongly of opinion that if the logs which were immersed in water had not been taken out during the hot weather, they would have given good results. It should be well worth while to carry out further tests in order to settle this point and also to immerse timber cut from green logs.

(*d*) *General remarks.*—The timber is strong and durable and, if properly seasoned, should find a ready market as planks and rafters for construction.

(7) **Bassia longifolia** (Appendix IV-7).

(*a*) *Locality where tested.*—North Division, Kanara, Bombay.

(*b*) *Best method of seasoning.*—The best results were obtained by converting green logs, but even this method of seasoning the timber was by no means ideal. It is quite likely that better results could be obtained by converting green logs, and at once immersing the timber in water for 4 to 6 weeks, followed by land seasoning, in a shed for 12 months.

(*c*) *Other methods of seasoning.*—Seasoning the log, with the ends treated with mud and cowdung, gave moderate results ; all other methods gave poor results.

(*d*) *General remarks.*—The timber is strong and fairly durable. If well seasoned, it should find a ready market as timber for construction work.

(8) **Bombax malabaricum** (Appendix IV-8).

(*a*) *Locality where tested.*—Siwalik and Ramnagar Divisions, United Provinces.

(*b*) *Best method of seasoning.*—The only method by which really satisfactory results were obtained, was by converting green logs, and immersing the planks at once in water for 4 weeks, followed by seasoning on land for upwards to 18 months. Even better results might be obtained by immersion for 6 weeks followed by 4½ months' seasoning in a shed. It is of great importance, when stacking this timber, to keep wedges between the planks in order to prevent discolouration ; while if the timber has to be stored for long periods, the stack should be periodically broken.

(*c*) *Other methods of seasoning.*—All other methods of seasoning gave very bad results.

(*d*) *General remarks.*—The timber is suitable for boarding and packing cases. The timber which was seasoned according to the method described in section (*b*) was utilized 4 years after conversion for rosin packing cases, and was at the time in perfect condition.

(9) **Cedrela Toona** (Appendix IV-9).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—The best results were obtained by girdling the trees, and conversion immediately after felling. Felling the trees after they had stood girdled for one year, gave slightly better results than by allowing them to stand for 18 months or two years. The sawn material should be carefully stacked under cover and seasoned for a further period of 6 to 12 months.

(*c*) *Other methods of seasoning.*—Slightly inferior results to those recorded above were obtained by seasoning the timber in the log, with bark on and with the ends smeared with either Loracine or Tar. The results obtained by seasoning the timber converted from green logs, as also by seasoning in the log with bark off were very unsatisfactory.

(*d*) *General remarks.*—This is an excellent timber for cutting into planks, and if properly seasoned will find a ready market.

(10) **Dalbergia latifolia** (Appendix IV-10).

(*a*) *Locality where tested.*—North Division, Kanara, Bombay.

(*b*) *Best method of seasoning.*—The best results have been obtained by seasoning the timber in rough hewn squares. The period of seasoning according to this method is from 18 to 24 months.

(*c*) *Other methods of seasoning.*—All methods of seasoning, other than green conversion, gave satisfactory results. When this timber is converted from green logs, and exposed to atmospheric influences it loses much of its colour, on which its value largely depends.

(*d*) *General remarks.*—This timber is often faulty in the centre so that when under conversion, it should be quartered so as to reject about 4″ of the core.

(11) **Dalbergia Sissoo** (Appendix IV-11).

(*a*) *Locality where tested.*—Ramnagar Division, United Provinces; and Lahore Division, Punjab.

(*b*) *Best method of seasoning.*—Girdling the trees for 18 months followed by conversion and seasoning for 12 to 18 months in the plank has given the best results. Probably 6 months in the plank after girdling would be sufficient, if in a dry locality.

(*c*) *Other methods of seasoning.*—Slightly inferior to girdling is immersion of the logs in water for 4 months, followed by land seasoning for a year and then conversion into planks and rafters. The worst results were obtained by seasoning the timber in the log, with bark off, which resulted in bad splitting.

(*d*) *General remarks.*—Mr. Parker, who carried out the final inspection at Changa Manga, Lahore Division, states that in order to obtain really good scantlings it is advisable to reject the centre of the log in conversion.

(12) **Dillenia pentagyna** (Appendix IV-12).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—The only method which gave satisfactory results was girdling the trees and leaving them standing for 2 to 2½ years, followed by conversion and seasoning under shelter for 6 months.

(*c*) *Other methods of seasoning.*—All other methods of seasoning produced rotten timber, with the exception of a small percentage of timber from logs seasoned in water and then on land.

(*d*) *General remarks.*—This timber yields excellent rafters and boards for internal work, though it decays rapidly if exposed to excessive moisture. If quartered, it shows a handsome silver grain rendering it suitable for wainscoting and panelling.

(13) **Diospyros Melanoxylon** (Appendix IV-13).

(*a*) *Locality where tested.*—South Chanda Division, Central Provinces.

(*b*) *Best method of seasoning.*—The best results have been obtained by girdling the trees and allowing them to stand for two years before felling, followed by 6 months' seasoning in the plank or scantling. Trees allowed to stand for three years showed signs of insect attack.

(*c*) *Other methods of seasoning.*—Slightly inferior results to those recorded above, were obtained by conversion from green logs, followed by immediate immersion of the rafters and planks in water for 6 to 8 months, and subsequent seasoning on land for upwards to 18 months. Timber seasoned in the log, either with or without bark, split considerably, while the former was heavily attacked by Longicorn borers. Water seasoning in the log also gave poor results, both in respect to splitting and insect attack.

(*d*) *General remarks.*—This timber is not suitable for conversion into planks, though suitable for posts, rafters, shafts, etc. When converting the logs, the core should be either rejected or put aside for special purposes.

(14) **Duabanga sonneratioides** (Appendix IV-14).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—The best results were obtained by girdling the trees, and allowing them to stand for a year to a year and a half. Trees which stood for 33 months were found to be attacked by borers. The timber deteriorates if exposed to excessive moisture and should therefore be seasoned off, in a shed for 6 to 12 months after the girdling period.

(*c*) *Other methods of seasoning.*—Planks converted from green logs do not deteriorate so fast as those cut from logs seasoned in the round, which, moreover, tend to split excessively.

(*d*) *General remarks.*—This timber is valuable for boarding, presents a good appearance and is durable under cover.

(15) **Grewia tiliæfolia** (Appendix IV-15).

(*a*) *Locality where tested.*—North Division, Kanara, Bombay.

(*b*) *Best method of seasoning.*—The best results were obtained by converting green logs. The timber was seasoned in the plank for 3 years, which proved to be an unnecessarily long period and resulted in the timber going back, 18 months being sufficient to ensure proper seasoning. It is probable that still better results could be obtained by immersing the timber in water for 4 to 6 weeks immediately after converting the green logs and then seasoning off on land for 16 to 18 months.

(*c*) *Other methods of seasoning.*—All other methods, by which the timber was seasoned in the log, gave poor results.

(*d*) *General remarks.*—This timber has attracted a good deal of attention from time to time, owing to its strength, elastic properties and durability. It must, however, be borne in mind that it is neither plentiful nor procurable free from defects in long lengths.

(16) **Lagerstrœmia Flos-Reginæ** (Appendix IV-16).

(*a*) *Locality where tested.*—Chittagong Division, Bengal.

(*b*) *Best method of seasoning.*—The best results were obtained by girdling trees and allowing them to stand for one year, followed by conversion and a further period of seasoning in the plank for 6 to 12 months. The trees allowed to stand girdled for 2 years yielded equally good, though not better, material.

(*c*) *Other methods of seasoning.*—Mr. Homfray, who inspected this timber, states that very fair results were obtained by converting green logs, followed by seasoning in the plank or scantling. From the record in Appendix IV it will be seen that this method actually gave the best results, as the method of recording adopted does not take into consideration fine cracks, which occurred in about 50 per cent. of the pieces examined. Seasoning in the log, either on land or first immersed in water, with or without ends treated gave relatively poor results.

(*d*) *General remarks.*—This is an excellent timber, suitable for all kinds of internal and external construction, and one which finds a ready market when in good condition.

(17) **Lagerstrœmia microcarpa** (Appendix IV-17).

(*a*) *Locality where tested.*—North and West Divisions, Kanara, Bombay Presidency.

(*b*) *Best method of seasoning.*—According to the particulars in Appendix IV, the best way of seasoning this timber is to leave it in the log, with bark on and ends tarred for a year or two, and then to convert the logs and season the sawn material in the shade for a year. This method has resulted in 29 per cent. of split timber. Taking the experiments as a whole, seasoning in the log has resulted in excessive splitting, whereas water seasoning in the log has reduced this defect to a minimum.

The methods of seasoning advocated are either immersion of the logs in water for a year, land seasoning for 6 months, followed by conversion and seasoning for 6 months under shelter or conversion of green logs, immersion of the cut material for 3 months, followed by 9 to 12 months seasoning under shade in well-stacked piles. From the records it appears that insect attack is local, and if this assumption is correct, then either of the methods advocated should give nearly perfect results.

(*c*) *Other methods of seasoning.*—Converting green logs has resulted in 52 per cent. of the timber splitting badly. The two defects from which this timber has suffered while seasoning are excessive splitting and insect attack. The former defect is serious in all cases of land seasoning, without previous immersion in water, whereas water seasoning has reduced this trouble to a minimum. It will be noticed that all the timber, both land and water, seasoned on the coast in the West Kanara Division has been heavily attacked by insects.

(*d*) *General remarks.*—A very sound, strong timber, useful for construction, boat-building, shafts, etc. Care taken in seasoning this timber according to correct methods will well repay the trouble and expense incurred.

(18) **Lagerstrœmia parviflora** (Appendix IV-18).

(*a*) *Locality where tested.*—Kurseong Division, Bengal; and South Chanda Division, Central Provinces.

(*b*) *Best method of seasoning*—

(*i*) *Timber from the log.*—The best results were obtained by girdling trees and allowing them to stand for one year, followed by seasoning in the plank for 6 months to a year. Trees allowed to stand for 2½ years were considerably damaged by borers.

(*ii*) *Pole wood.*—The best results were obtained either by felling in August, and seasoning the poles with bark on or by immersing the poles directly after felling, allowing them to remain in the water for 4 to 6 weeks and subsequent drying on land for upwards to a year.

(*c*) *Other methods of seasoning*—

(*i*) *Timber from the log.*—Little inferior to the results obtained by girdling in Kurseong, were those from experiments carried out in South Chanda, by which the logs were converted green and the material immersed in water for 5 to 9 months, followed by seasoning on land in a shed for a year or more. All methods by which the timber was seasoned in the log, resulted in excessive splitting.

(*ii*) *Pole wood.*—There is little difference in the poles felled in January and April, and seasoned either with or without bark; they were all in very fairly good condition.

(*d*) *General remarks.*—This timber is naturally very faulty and therefore is not suitable for cutting into planks; on the other hand, if properly seasoned, it produces moderately good rafters and scantlings and good posts.

(19) **Machilus odoratissima** (Appendix IV-19).

(*a*) *Locality where tested.*—Darjeeling Division, Bengal.

(*b*) *Best method of seasoning.*—Mr. Gent, who inspected this timber, states that distinctly the best results have been obtained by girdling the trees, the logs from which have produced good sound timber. The trees require very careful girdling owing to the fluted nature of the stems. The girdling period is fixed at 3 years.

(*c*) *Other methods of seasoning.*—Seasoning the timber in the log, with bark off and untreated ends, yielded timber little inferior to that obtained from girdled trees, while logs with treated ends and bark on were attacked by fungus, due no doubt to retention of moisture in the timber. Converting the timber from green logs and water seasoning both gave poor results.

(*d*) *General remarks.*—A good sound timber, useful for internal construction.

(20) **Michelia Champaca** (Appendix IV-20).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—The best results were obtained by girdling the trees and allowing them to stand for 2½ years, followed by 6 months' seasoning in the plank or scantling, while by girdling for only 1 year nearly equally good results were obtained.

(*c*) *Other methods of seasoning.*—Seasoning in the log, either with ends treated or untreated, resulted in a considerable amount of splitting. Conversion from green logs gave very poor results, while immersion of the logs in water gave no better results than land seasoning in the log.

(*d*) *General remarks.*—Converted planks and scantlings should be stored under shelter, as the timber is liable to deteriorate from fungus attack. It is also somewhat liable to attack by borers, if seasoned in the log.

(21) **Morus indica** (Appendix IV-21).

(*a*) *Locality where tested.*—Lahore Division, Punjab.

(*b*) *Best method of seasoning.*—The best results have been obtained by girdling the trees and allowing them to stand for 12 months, followed by 6 to 12 months' seasoning in the plank or scantling, but even this treatment does not obviate the tendency of the wood to warp.

(*c*) *Other methods of seasoning.*—Slightly inferior to the timber obtained from girdled trees, was that from logs seasoned with bark on and the ends treated with Loracine. Logs, the ends of which were treated with either tar or cowdung and mud gave poor results, which indicates that such substances are not sufficiently dense for use in very hot climates. Timber converted from green logs was of poor quality.

(*d*) *General remarks.*—The chief defect in this timber is its tendency to warp badly. This can be overcome to a great extent by careful quartering of the logs and by never including the whole core of the tree in a scantling or beam. The timber is used by the trade for sporting requisites and small articles such as bedstead legs, when slight warping is of no great consequence.

(22) **Ougeinia dalbergioides** (Appendix IV-22).

(*a*) *Locality where tested.*—North Division, Kanara, Bombay; and South Chanda Division, Central Provinces.

(*b*) *Best method of seasoning*—

(*i*) *Timber from the log.*—The best results obtained in Bombay were by either seasoning in rough squares for a year or more and subsequent seasoning in the plank for a year or by converting the logs when green and seasoning in the plank for 12 to 18 months. In South Chanda the best results were obtained by felling either in January or August, and seasoning in the log for a year, followed by 6 to 12 months' seasoning in the plank. A reference to Appendix IV will show that in no instance was splitting serious, though attack by borers was in some cases severe.

(*ii*) *Pole wood.*—Poles were felled in January, April and August, while others were felled in January and at once immersed in water. In all cases, the results were equally satisfactory.

(*c*) *Other methods of seasoning*—

(*i*) *Timber from the log.*—Slightly inferior to the results enumerated above, were those obtained by immersing the logs in water for three months and seasoning for a year on land, followed by 6 months' or more seasoning in the plank. The South Chanda Experiments show that if the timber is seasoned in the log, it must be barked; otherwise, it is very liable to attack by borers. The season of felling does not appear to affect the timber, nor do the results of other experiments differ very much from those already mentioned, as this timber is not liable to excessive splitting.

(*ii*) *Pole wood.*—Nil.

(*d*) *General remarks.*—Internal defects especially near the centre are very common in this timber; it, therefore, follows that the core should be rejected in conversion. The timber should be stored under cover to preserve its good appearance and colour. This timber produces excellent cart-shafts, axles and building material from the log and good poles and posts from small trees.

(23) **Pinus longifolia** (Appendix IV-23).

(*a*) *Locality where tested.*—Rawalpindi and Kangra Divisions, Punjab.

(*b*) *Best method of seasoning.*—The best results have been obtained both in Rawalpindi and Kangra by converting green logs into sleepers, scantlings and boards. A period of not more than 12 months' seasoning for converted material is advocated: the timber should preferably be carried out under cover.

(*c*) *Other methods of seasoning.*—Seasoning in the log, with or without ends treated, has given quite good results in some cases and bad in others; though, generally speaking, cracking is more prevented than in the case of timber cut from green logs. Barking logs has a bad effect, resulting in excessive splitting and often serious damage by borers. Mr. Wright, who inspected the Kangra experiment, states that by removing the bark from logs the oils and resins evaporate quickly and thus remove protection from insect attack. The material converted from green logs, on the other hand, exudes much resin at the ends

CORRIGENDUM SLIP

Page 16, 11th line from bottom, *for* "the timber should" *read* "the seasoning should".

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and on the surface which, in his opinion, is the reason for such timber being immune from insect attack.

"S" clamps were attached to some of the B. G. sleepers prepared from green logs; in Rawalpindi the sleepers, with or without such clamps, were in much the same condition, while in Kangra, those fitted with these clamps were considerably more split than those without.

(*d*) *General remarks.*—Chir timber, and especially that from the Eastern zone, is very liable to warp. Converting the material from green logs certainly reduces the tendency to do so (see Forest Bulletin No. 37 of 1917, on "Contraction and Warping of *Pinus longifolia* timber"). To further obviate this tendency to warp, sleepers, scantlings and boards should be stacked in piles built up as high as practicable in order to take every advantage of weighting the timber.

(24) **Pterocarpus Marsupium** (Appendix IV-24).

(*a*) *Locality where tested.*—Sambalpur, Bihar and Orissa; North Division, Kanara, Bombay; and South Chanda Division, Central Provinces.

(*b*) *Best method of seasoning.*—By converting green logs into planks and scantlings, which should be immersed in water for 6 weeks in the case of running water and up to 4 months, if stagnant, followed by seasoning on land for 12 months, in well-stacked open piles, if possible under cover.

(*c*) *Other methods of seasoning.*—The next best results were obtained by converting green logs, not followed by immersion in water. Seasoning in the log on land, or by first immersing the logs in water, did not result in excessive splitting, though this defect was more marked in the case of logs without than with bark on. Seasoning by any method in the log renders the timber very liable to bad discolouration, which is nearly entirely overcome by immersing converted material in water.

(*d*) *General remarks.*—The timber is liable to be faulty in the centre and, therefore, when converting logs, the core, *viz.*, a $4'' \times 4''$ rafter, should first be cut out. One of the great defects of this timber is the objectionable colouring matter, which debars its use for furniture and other purposes. Water seasoning of converted material overcomes this difficulty to a large extent. In order to ascertain the effect of immersion on timber experimented with at Sambalpur, shavings were cut out of (i) planks which had been immersed in water for 4 months, and subsequently seasoned on land, (ii) planks cut from logs which had been immersed for 4 months and subsequently seasoned on land and (iii) planks cut from logs seasoned on land. To the three samples of shavings equal parts of water were added and each gently warmed and mulsed in order to extract the colouring matter from the chips. The result was that sample (ii) gave a deep red purple decoction, the colour from sample (iii) was of slightly greater density than that of sample (ii), while sample (i) yielded a pale light yellow colour. The general appearance of all three sets of planks fully corroborated the above results.

(25) **Schima Wallichii** (Appendix IV-25).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—Markedly the best results were obtained by girdling the trees and allowing them to stand for 18 months, which should be followed by a six months' seasoning period in the plank. Allowing the trees to stand girdled for $2\frac{1}{2}$ years did not give quite such good results as the above.

(*c*) *Other methods of seasoning.*—Fair to good results were obtained by converting green logs, followed by seasoning in the plank. The various methods tried by which the timber was seasoned in the log gave poor results, the timber being attacked by fungus.

(*d*) *General remarks.*—The local idea is that this timber does not yield good planks, but this idea is not corroborated by results obtained from girdled timber, which yields excellent planks and scantlings. As the timber is liable to fungus attack while seasoning, it should be stored under cover.

(26) **Shorea robusta** (Appendix IV-26).

(*a*) *Locality where tested.*—Haldwani Division, United Provinces; and Singhbhum Division, Bihar and Orissa.

(*b*) *Best method of seasoning.*—No very definite results have been obtained. Mr. Collier, who inspected the Haldwani timber, is of opinion that seasoning in the log, in the shade for 20 months followed by 12 months' seasoning of the converted material, gave the best results. Mr. Dodsworth who inspected the timber in Singhbhum, considers that the best results were obtained by immersing the logs in water for 4 months, followed by 14 months' seasoning on land and subsequent conversion, and seasoning the converted material under cover for a year.

(*c*) *Other methods of seasoning.*—By whatever method the timber is seasoned, heavy splitting has not taken place, though a fair amount of slight splitting and, in some cases, warping has occurred. From all the evidence available it does not appear that water seasoning has given sufficiently definite results to justify the adoption of this method of seasoning. Green conversion has not given results much inferior to seasoning in the log. The only marked point brought out by the experiments is that in Singhbhum seasoning in the log has resulted in serious damage by borers.

(*d*) *General remarks.*—The timber is too well known to require description.

(27) **Stephegyne parvifolia** (Appendix IV-27).

(*a*) *Locality where tested.*—South Chanda Division, Central Provinces.

(*b*) *Best method of seasoning.*—The best results, which were even then not altogether satisfactory, were obtained by girdling trees and leaving them standing for 18 months, followed by 6 months' seasoning in the plank.

(*c*) *Other methods of seasoning.*—The season of felling does not appear to affect the timber. All timber seasoned in the log, either with bark on or with bark off, suffered from borers. Water seasoning in the log gave poor results.

(*d*) *General remarks.*—Conversion of green logs, followed either by seasoning in a shed or immersion in water for 6 to 8 weeks might give even more satisfactory results than girdling and should be tried.

(28) **Tectona grandis** (Appendix IV-28).

(*a*) *Locality where tested.*—South Chanda, Central Provinces.

(*b*) *Best method of seasoning*—

(*i*) *Timber from the log.*—The best results were obtained by girdling trees and leaving them standing for 2 to 3 years, followed by a 15 months' seasoning period in the plank after conversion.

(*ii*) *Pole wood.*—The best results were obtained by felling in August, immersing the poles at once in water for 2 to 3 months, followed by seasoning on land for 9 months.

(*c*) *Other methods of seasoning*—

(*i*) *Timber from the log.*—Cracking was excessive in timber cut from logs felled in January and April, but not so marked in that felled in August. Green logs immersed in water for three months produced timber which was seriously cracked.

(*ii*) *Pole wood.*—Poles felled in January and April, and seasoned either with bark on or with bark off, were badly cracked; those felled in August were not so badly cracked as the above but more so than water seasoned poles.

(*d*) *General remarks.*—When reviewing the results of these experiments, it must be borne in mind that they probably only apply to Teak grown in the dry zone and seasoned in a locality where temperatures run high from March to June. There are, however, extremely instructive in that they show that even a timber of the quality and high reputation of Teak requires careful treatment.

(29) **Terminalia Arjuna** (Appendix IV-29).

(*a*) *Locality where tested.*—South Chanda Division, Central Provinces; and Jhansi Division, United Provinces.

(*b*) *Best method of seasoning.*—In South Chanda, equally good results were obtained by felling in January and seasoning in the log, with bark on, for 24 months followed by seasoning in the plank for a year and by girdling the trees and allowing them to stand for 24 months, followed by seasoning in the plank for a year. In Jhansi Division the best results were obtained by converting green logs, and seasoning the planks under cover for 24 months. In the Chanda experiments 85 per cent. and in the Jhansi experiments 76 per cent., of sound timber was obtained from seasoning by the above described methods.

(*c*) *Other methods of seasoning.*—Logs felled either in April or August yielded timber which cracked considerably, while those logs which were seasoned with bark on suffered from borers. Logs left in the forest in the shade, suffered from borers, especially the sap-wood which was entirely destroyed. Logs immersed in water, warped and cracked seriously both in Chanda and Jhansi.

(*d*) *General remarks.*—The timber is liable to warp badly, so should be stacked in as high piles as permissible. It is a good sound timber if properly seasoned, more suitable for scantlings and posts than for planking.

(30) **Terminalia belerica** (Appendix IV-30).

(*a*) *Locality where tested.*—Kurseong Division, Bengal.

(*b*) *Best method of seasoning.*—The only satisfactory method of dealing with this timber is to girdle the trees and to leave them standing for 12 to 18 months, followed by felling and conversion and subsequent seasoning for a short period in a shed.

(*c*) *Other methods of seasoning.*—All other methods of seasoning yielded rotten timber due to fungus and insect attack. Converting green logs, immersing the sawn material at once in water, followed by seasoning in a shed was not tried, though it is thought that it might yield good results.

(*d*) *General remarks.*—This is a low grade timber though, if properly handled, it would no doubt yield fair rafters for internal work, if well protected by paint or creosote.

(31) **Terminalia paniculata** (Appendix IV-31).

(*a*) *Locality where tested.*—North and West Divisions, Kanara, Bombay Presidency.

(*b*) *Best method of seasoning.*—The methods which have given the best results are either by converting the logs when green and storing the sawn material for 12 to 18 months under cover, or by immersing the logs in tidal creeks for a year, followed by 15 months' seasoning on land and subsequent conversion and a further short period of seasoning of the sawn material.

(*c*) *Other methods of seasoning.*—Seasoning in the log, on land, with or without bark and with or without ends treated with a protective substance resulted in excessive splitting.

(*d*) *General remarks.*—It is possible that converting green logs, followed by immersion for 2 or 3 months and subsequent seasoning in open stacks under cover, would give even better results than those enumerated above.

The timber is strong and suitable for construction rather than for high class work, such as furniture.

(32) **Terminalia tomentosa** (Appendix IV-32).

(*a*) *Locality where tested.*—South Chanda Division, Central Provinces; and Kheri Division, United Provinces.

(*b*) *Best method of seasoning*—

(*i*) *Timber in the log.*—Converting timber from green logs either with or without subsequent immersion in water and then seasoned in the shade for 12 to 18 months, gave by far the best results both in South Chanda and Kheri.

(*ii*) *Pole wood.*—Poles felled in August, and seasoned with bark on for 9 to 12 months have given the best results.

(*c*) *Other methods of seasoning*—

(*i*) *Timber in the log.*—The results of girdling trees were quite satisfactory in South Chanda, though the trees which were allowed to stand for over 2 years were seriously damaged by borers. Fair to good results were also obtained in both divisions by immersion of the timber in the round for upwards to 3 months, though conversion of green logs and immersion of the sawn material is distinctly preferable. All methods of seasoning in the log on land gave relatively poor results. It was noticeable that the timber seasoned with bark on suffered much more heavily from insect attack than that with bark off.

(*ii*) *Pole wood.—Terminalia tomentosa* poles do not appear to be subject to excessive cracking while seasoning, though those felled in January and April are not in quite such good condition as those felled in August. Poles immersed in water after felling cracked badly.

(*d*) *General remarks.*—The question of ascertaining the best ways of dealing with this timber is of great importance, as large quantities are available from most parts of British India : while it is a sound strong timber, very useful for construction, bridging and sleepers after treatment and for many other purposes. It is more suitable for posts, beams and scantlings than for boards, though suitable for cutting into thick planks for bridging, etc. It should never be allowed to lie in the log longer than is absolutely necessary.

(33) **Xylia xylocarpa** (*West Coast*) (Appendix IV-33).

(*a*) *Locality where tested.*—North and West Divisions, Kanara, Bombay Presidency.

(*b*) *Best method of seasoning.*—The best results have been obtained by immersing the logs for a year in tidal creeks, followed by seasoning the logs on land for 9 months, and subsequent conversion and seasoning for a short period in open stacks under cover. Where water seasoning is not feasible the logs must be converted as soon after felling as possible.

(*c*) *Other methods of seasoning.*—All ways by which the timber is seasoned in the log results in upwards to 100 per cent. of split material. Conversion of green logs, followed by water seasoning for about 3 months and subsequent seasoning on land was not tried, though it is thought that good results could be obtained by this method.

(*d*) *General remarks.*—A strong timber, though difficult to season ; useful for construction, sleepers, paving-blocks, etc.

APPENDIX I.

SCHEME ACCORDING TO WHICH THE EXPERIMENTS WERE CARRIED OUT.

[*Enquiry No. 8* (c) *of the Triennial Programme of work for 1916 to 1919.*]

Chief Conservators and Conservators of Forests were recently requested to inform this office of any experiments carried out and methods employed in their Provinces and Circles by which timber is seasoned, to make suggestions as to the species to be tested and the lines along which the enquiry should be carried out, while all Sawmill managers and large firms in India and Burma were also addressed on the subject. From the replies received it appears that the seasoning of timber is not commonly practised in India, though some useful information is available from experiments carried out locally. The reports received from the various provinces show that the local officers look upon such an enquiry as is now proposed as being of very considerable importance, and many proposals have been made by the Conservators and Divisional Forest Officers as to the species to be tested and the lines along which the experiments should be carried out. In dealing with so extensive an experiment it will, therefore, be necessary to ask each province to co-operate with the Forest Research Institute in carrying out the enquiry with those species of timber in which they are especially interested.

The importance of such an enquiry is too well known to require anything further being said in justification of its being taken up, for not only does proper seasoning increase the durability of the timber and in a large measure reduce its tendency to slipt, warp and shrink, besides being absolutely necessary in connection with treating timber, but it is thought that many trial lots of timber which have been submitted from time to time to timber dealers and firms for testing or for introducing as new timbers on the market have been pronounced unsuitable for the purpose owing to their tendency to warp, crack or contract for want of proper seasoning.

2. After perusal of the available literature on the subject, it is proposed to carry out an enquiry on the following points :—

To determine the relative merits of seasoning timber under the following conditions :—

(*i*) (*a*) The effect on the timber of certain species by girdling the trees before they are felled.

(*b*) Seasoning in the open.

(*c*) Seasoning under shelter with a free circulation of air.

(*d*) Seasoning first in water and afterwards under shade, with free circulation of air.

(*e*) The effect of burying timber in the tidal creeks and then seasoning under shade in the open.

(*ii*) The effect of felling at different times of the year, and in this connection (*a*) to ascertain the best season of the year in which to fell timber, (*b*) to ascertain the amount of moisture in the sap and heart-wood respectively at different periods of the year, (*c*) to ascertain the rate of absorption and re-evaporation of moisture from timber immersed in water, *i.e.*, after having been dried under shade in the open, (*d*) to ascertain the rate of seasoning of the timber under heads (*i*) (*a*) to (*c*), and (*e*) to ascertain the relative absorption of water by green and seasoned timber.

(*iii*) The effect produced by converting certain timbers when green and in a dry state, and in this connection the best methods of—

(*a*) Seasoning and stacking such timber.

(*b*) To study the question of the discolouration of timber converted before or after seasoning.

(*c*) To study the question of immersion of timber in connection with discolouration.

(*iv*) To study the results obtained by applying Ligno, Loracine, tar and cowdung to the ends of logs while seasoning and the use, if any, of metal clamps to prevent timber in the log and when converted into sleepers, from splitting.

(*v*) To study the amount of contraction across the grain which takes place in timber of various species while seasoning.

(*vi*) To study the effect of barking trees on the mode and rate of seasoning.

3. In order to carry out so extensive an enquiry as is outlined above, and especially as many portions of the enquiry will extend over several years, it is absolutely necessary to work out in detail each item of enquiry and to select such species with which to carry out the investigation, as will ultimately give the most useful results to the Department. The Conservators in answering the letter addressed to them on this subject have suggested species with which, in their opinion, test should be made and. in the majority of cases, these will be dealt with in this enquiry.

4. The lines on which it is proposed to deal with the above heads and sub-heads of enquiry are as follows :—

I.—Burma.

Based on the reports received from the Chief Conservator of Forests, and his Conservators it is proposed to ask them—

(*i*) (*a*) to girdle 6 trees of :—(1) *Lagerstrœmia Flos-Reginæ,* (2) *Gmelina arborea,* (3) *Dipterocarpus alatus,* (4) *Dipterocarpus tuberculatus,* (5) *Cedrela Toona,* (6) *Pterocarpus macrocarpus,* (7) *Schleichera trijuga,* (8) *Pentacme suavis,* (9) *Melanorrhœa usitata,* (10) *Hopea odorata,* (11) *Berrya Ammonilla, and* (12) *Adina cordifolia.* To convert the above timber into planks and scantlings after being girdled for 3 years and then felled, in order to compare it with the converted material prepared according to the methods described below.

(*ii*) To fell six other trees of each of the above species, in order to (*i*) (*e*) prepare logs from the same 6 ft. long, and season two of each according to (*i*) (*b*), (*i*) (*c*), (*i*) (*d*) and (*i*) (*e*) ; after these logs are seasoned, they will be converted into planks to be compared with those to be converted green as described in the next para.

(*iii*) (*a*) To convert green logs into planks of the above twelve species and also of (13) *Xylia dolabriformis* and (14) *Fagrœa fragrans* which will be (1) stacked in the shade in open piles and weighted above. (2) First immersed in water for six weeks after conversion and then stacked in open piles in the shade.

(*iv*) To prepare 10 M. G. sleepers of (1) *Dipterocarpus alatus,* (2) *Dipterocarpus tuberculatus,* (3) *Xylia dolabriformis,* (4) *Schleichera trijuga,* (5) *Lagerstrœmia Flos-Reginæ,* (6) *Pentacme sauvis* from—

(*a*) Green logs.

(*b*) Seasoned logs.

(*c*) Logs treated with Loracine or Ligno and then seasoned.

(*d*) Logs treated with cowdung and tar mixed and then seasoned.

(*e*) Seasoned logs and fix iron " S " shaped clamps to each end of the sleeper after preparation. Such an experiment will entail the preparation of 300 M. G. sleepers.

II.—Bihar and Orissa.

The Conservator of Forests, Bihar and Orissa, requests that enquiries may be made as to the seasoning properties of Sâl (*Shorea robusta*) and Bija (*Pterocarpus Marsupium*). As regards Sâl, experiments are already in progress at Dehra Dun which cover (*i*) (*a*), (*i*) (*b*) and (*i*) (*c*), also (*ii*) (*a*) and (*ii*) (*b*), so need not be repeated. It is proposed to request the Conservator to fell 6 trees of Sal and Bija, the logs from which will be treated as follows :—

(*i*) (*d*) To season 6 logs, first in water and afterwards under shade with free circulation of air.

(*iii*) (*a*) (1) To convert the above logs, after seasoning, into planks and stack them in open piles, under shade.

(2) To convert green logs of the above species into planks and stack them in open piles, under shade.

(3) To convert 6 green logs of the above species into planks, immerse them in running water for six or eight weeks, and then season in open piles, under shade. It may be necessary to leave the Bija planks longer in water so as to get rid of the objectionable colouring matter.

(*iv*) & (*vi*) To prepare logs 6 ft. long of Sâl and Bija, 3 for each of the following experiments, to be seasoned :—

(*a*) Without ends treated, with bark on.

(*b*) Without ends treated, with bark off.

(*c*) With ends treated with cowdung and tar mixed, with the bark left on.

(*d*) With ends treated with Loracine or Ligno, with the bark left on.

III.—United Provinces.

The Conservators of the United Provinces recommended the following species for experiment :—(1) *Shorea robusta*, (2) *Terminalia tomentosa*, (3) *Bombax malabaricum*, (4) *Albizzia Lebbek*, (5) *Dalbergia Sissoo*, (6) *Bassia latifolia* and (7) *Terminalia Arjuna*.

Experiments with hill and plains grown United Provinces Sâl, cut at different seasons of the year, are in progress, so need not be repeated. The following experiments are therefore suggested :—

(*i*) (*d*) Seasoning 6 logs, 6 ft. long of the above species, by complete immersion in water for 4 months, and afterwards under shade until they are air dry, and at the same time to lay down 6 logs of each species to season in the shade. The relative merits of above two methods of seasoning can then be compared.

(*iii*) (*a*) To convert green logs of all the above 7 species into planks and season them, piled in open stacks with weights above. Also to convert into planks the logs after they are seasoned according to methods suggested under (*i*) (*d*) and to compare their state, when dry, with the boards converted from green logs.

(*b*) & (*c*) In carrying out the above experiments special attention will be paid to the question of discolouration of *Bombax malabaricum*, the logs of which will have to be entirely immersed during the water-seasoning process.

IV.—Central Provinces.

The Chief Conservator of Forests and Conservators of Forests of the Central Provinces in their reports on seasoning timber lay special stress on felling in the rains and water-seasoning. The following experiments are proposed to be carried out in the Central Provinces with (1) Teak, (2) *Terminalia tomentosa*, (3) *Pterocarpus Marsupium*, (4) *Lagerstrœmia parviflora*, (5) *Diospyros Melanoxylon*, (6) *Ougeinia dalbergioides*, (7) *Terminalia Arjuna*, (8) *Adina cordifolia, and* (9) *Stephegyne parvifolia.*

(*i*) (*a*) To girdle 10 trees of each of the above species to determine the mode of seasoning by doing so.

(*d*) Seasoning poles of the above species in water for 2 to 4 months, and afterwards in open stacks in the shade, and placing a similar number of poles of each species to season in the shade without previously being immersed in water, this for comparison.

(*ii*) (*a*) To fell poles of the above species in January, April and August or September, and place them to season, some with bark on and some stripped, stacked in open piles in shady places.

(*b*) To ascertain the amount of moisture in the timber felled in January, April and August (*a*) at time of felling the trees mentioned in (*ii*) (*a*) and (*b*) when seasoned, *i.e.*, to form an idea of the rate of seasoning. *

(*vi*) In connection with (*ii*) (*a*) to study the effect on the timber of barking and not barking poles when seasoning.

* NOTE :—The moisture tests will be carried out at Dehra Dun.

V.—Bombay.

The Conservators of Forests, Northern and Southern Circles, and their Divisional Forest Officers make certain suggestions as regards experiments which might be carried out. Based on these reports, the following are suggested :—

(*i*) (*a*) To girdle 6 of each of the following species—(1) *Terminalia paniculata*, (2) *Lagerstrœmia microcarpa*, (3) *Pterocarpus Marsupium*, (4) *Dalbergia latifolia*, (5) *Grewia tiliaefolia*, (6) *Adina cordifolia*, (7) *Ougeinia dalbergioides*, (8) *Xylia xylocarpa*, (9) *Bassia longifolia*.

(*c*) Seasoning 6 logs of each of the above species under a shelter, 3 being roughly squared, and 3 left in the round.

(*e*) To bury 6 logs of No. 1, 2, 6 and 8 in mud in a tidal creek, for 6 or 8 months, and afterwards leave them to season in a shady place.

(*iv*) To lay down 6 logs of the above 9 species—(*i*) with ends treated with Ligno or Loracine, (*ii*) with tar and (*iii*) with mud and cowdung. These logs to be seasoned with bark on, and in the same place as those mentioned under (*i*) (*c*).

(*iii*) (*a*) To convert green logs into planks of the above species and to convert all the logs mentioned under (*i*) (*a*), (*i*) (*c*), (*i*) (*e*) and (*iv*) into planks after they are seasoned, so as to compare the value of the different methods of seasoning.

VI.—Bengal.

The Conservator of Forests and his Divisional Forest Officers propose several experiments to be made with different species, based on which the following experiments are suggested :—

(*i*) (*a*) To girdle 6 trees of—(1) *Artocarpus Chaplasha*, (2) *Cedrela Toona*, (3) *Anthocephalus Cadamba*, (4) *Michelia Champaca*, (5) *Terminalia belerica*, (6) *Chickrassia tabularis*, (7) *Schima Wallichii*, (8) *Dillenia pentagyna*, (9) *Gironniera reticulata*, (10) *Lagerstrœmia parviflora*, (11) *Albizzia* spp., (12) *Lagerstrœmia Flos-reginœ* and (13) *Duabanga sonneratioides*, and afterwards convert the logs into boards and stack them in open piles.

(*d*) To season logs of the above species in water, with bark off, for 3 to 6 months, then allow them to dry in a shady place and finally convert them into boards stacked in open piles.

(*iii*) To convert green logs of the above species into planks and store in open piles.

(*iv*) To lay down logs of the above species with bark on and the ends smeared, (*i*) with Loracine or Ligno, (*ii*) with tar or cow-dung and earth, and after seasoning to convert them into planks and stack the same in open piles.

(*v*) In order to compare the relative merits of the above methods of seasoning, to lay down a few logs of each species to season with bark off in the open.

VII.—Assam.

(*iii*) (*a*) to (*c*) To attempt to find out methods of preventing discolouration of tea-box woods such as *Bombax malabaricum* and *Tetrameles nudiflora.* Such experiments will have to be carried out, in the first place, on a laboratory scale at Dehra Dun, after which it may be possible to lay down definite lines along which further enquiry should be carried out. The Conservator of Forests, Western Circle, makes no suggestions as to other experiments but were he to care to do so, after perusing the proposals made for experiments in other Provinces, they could be added to this scheme of enquiry.

VIII.—Punjab.

The Conservator of Forests, Punjab, expresses a wish that seasoning experiments should be carried out with (1) *Dalbergia Sissoo,* (2) *Morus indica,* (3) *Terminalia tomentosa,* (4) *Lagerstrœmia parviflora* and (5) *Eucalyptus* spp.; he also forwards several valuable records of experiments submitted by the Divisional Forest Officers. Based on these suggestions, it is proposed to carry out the following experiments :—

(*i*) (*a*) To ascertain the effect of girdling trees of species Nos. 1, 2 and 5.

(*i*) (*c*) & (*vi*) To season logs of all the above five species, plus *Pinus longifolia,* in the shade with bark off and afterwards converting them into planks and scantlings.

(*iii*) To ascertain the effect of converting green logs of the above species, plus *Pinus longifolia,* into boards and scantlings and stacking them carefully in open piles, weighted on the top.

(*iv*) & (*vi*) To season logs of the above species, and also (6) *Pinus longifolia* with bark on, and the ends protected (*i*) with Loracine or Ligno, (*ii*) with tar, (*iii*) with cowdung and earth, and afterwards converting the logs of species Nos. 1, 2, and 4 into planks and boards and Nos. 3, 5, and 6 into sleepers with " S " clamps fitted to the ends.

IX.—Madras.

The Conservators of Forests in Madras make no suggestions ; if, however, they wish experiments carried out, they can be added to this scheme.

APPENDIX II.

Form I.—Seasoning enquiry—Form in which to enter results of Experiments under heads (i) (a) to (i) (e), (iii) (a), (iv) and (vi).

Serial No. of log.	Mode of seasoning to be adopted.	Species.	Size of tree, log, sleeper, board or scantling.	Date of felling the tree.	Date of girdling the tree.	Date of laying down to season, either on land, or in water or in tidal creek.	Date of removal from water or tidal creek.	Date of conversion into planks and scantlings.	Date of inspection.	Inspection notes.
1	2	3	4	5	6	7	8	9	10	11

Form II.—Seasoning enquiry—Form in which to enter results of Experiments under head II.

Serial No. of log.	Mode of seasoning to be adopted.	Species.	Size of tree or log.	Date of felling.	Percentage of moisture in timber on date of felling.		Percentage of moisture in timber when seasoned.		Date of inspection.	Inspection note.
					Heartwood.	Sapwood.	Heartwood.	Sapwood.		
1	2	3	4	5	6		7		8	9

APPENDIX III.

Inspection note— *Interim report ;*
Final

Date of inspection.

Name of Division..............................

Head of Experiment..............................

Species..............................

[33]

DESCRIPTION OF SPECIMEN.			Sound in all resp cts..	SLIGHTLY SPLIT.		BADLY SPLIT.		Surface cracks.	Slightly warped.	Badly warped.	Discolour-ation, if any.	Insect attack, if any.	Per cent. of moisture at time of in-spection.	REMARKS.
No. on log.	No. on converted timber.	Size of log or converted timber.		One end.	Other end.	One end.	Other end.							
1			2	3		4		5	6	7	8	9	10	11

NOTE.—(1) By " slightly split " should be understood a crack of under 1 ft. in length and not over ½ in. broad, otherwise it should be recorded under " Badly cracked."

(2) Surface cracks, as occur for instance in Sal, should be recorded by stating the number per foot across the grain at a point where about the average number occur.

(3) " Slightly warped " should include only serviceable timber. " Badly warped " means unserviceable timber for carpentry or constructional purposes.

(4) Moisture tests will be arranged for by the Forest Economist either by obtaining sample planks or rafter or by obtaining samples of the timber in closed specimen tubes and carrying out the moisture tests at Dehra Dun.

APPENDIX IV.

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(1) *Adina cordifolia*	N. D. Kanara, Bombay.	Natural seasoning in log, with bark on and then converted.	27	17·49	60	33	..	7	Fair.
Ditto	Do.	Seasoned in rough squares and then converted.	30	..	80	20	..	..	Do.
Ditto	Do.	Seasoned in log, with ends coated with Loracine and then converted.	28	..	67	29	..	7*	Do.
Ditto	Do.	Seasoned in log, with a cut to centre, and then converted.	20	..	80	20	..	..	Do.
Ditto	Do.	Seasoned in log, with ends treated with cowdung and mud and then converted.	29	..	30	65	3	3*	Poor.
Ditto	Do.	Converted green, and seasoned in plank.	**23**	**19·25**	**83**	**17**	..	..	Good.
Ditto	Do.	Seasoned in log, with ends treated with tar, and then converted.	33	16·17	70	30	..	..	Fair.
Ditto	W. D. Kanara, Bombay.	Seasoned in log, in shade, for 21 months, then converted in October and seasoned in planks and scantlings for 18 months.	10	..	50	40	..	10	Surface cracking slight, discolouration *nil*.
Ditto	Do.	Seasoned in log, in shade for 27 months, then converted in April and seasoned in planks and scantling for 12 months.	**6**	..	**83**	**17**	..	..	Some surface cracking, no discolouration.
Ditto	Do.	Logs immersed in tidal creek for 12 months, then seasoned in log on land for 9 months, converted in October and seasoned in plank and scantling for 18 months.	21	..	66	20	5	15*	Somewhat discoloured and about 50 per cent. of the pieces very slightly warped.

Ditto . .	Do. .	Logs immersed in tidal creek for 12 months, then seasoned in log on land for 15 months, converted in April and seasoned in plank and scantlings for 12 months.	47	..	54	32	10	6*	A good deal of discolouration and a high percentage of pieces slightly cracked.
Ditto . .	S. Chanda, Central Provinces.	Felled in January, seasoned with bark off in log, and then converted.	17	..	36	53	..	17*	Poor.
Ditto . .	Do. .	Felled in January, seasoned with bark on in log and then converted.	19	..	15	68	..	53*	Do.
Ditto . .	Do. .	Felled in April, seasoned in log with bark off, and then converted.	18	..	..	100	..	..	Very poor.
Ditto . .	Do. .	Felled in April, seasoned in log with bark on and then converted.	15	..	14	40	..	73*	Poor.
Ditto . .	Do. .	Felled in August, seasoned in log with bark off and then converted.	15	..	14	86	..	..	Do.
Ditto . .	Do. .	Felled in August, seasoned in log with bark on and then converted.	16	16·78	..	86	..	93*	Very poor.
Ditto . .	Do. .	Logs seasoned in water for 3 months, and on land for 17 months and then converted.	46	18·10	42	50	..	10*	Fair.
Ditto . .	Do. .	Girdled for 22 months, then felled and converted.	**18**	**17·83**	**73**	**22**	..	5	Good.
(2) *Albizzia odoratissima*	Lansdowne Division, United Provinces.	Log seasoned in water for 4 months and then converted.	20	19·73	50	50	..	..	Fair.
Ditto . .	Do. .	Logs seasoned in water for 4 months, and on land for 15 months and then converted.	14	13·09	50	50	..	..	Do.
Ditto . .	Do. .	Natural seasoning in log for 2 years and then converted.	**26**	**12·67**	**81**	**19**	..	..	Do.

*NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(2) *Albizzia odoratissima*—contd.	Lansdowne Division, United Provinces.	Natural seasoning in log for 19 months and then converted.	16	18·42	75	25	..	..	Good.
(3) *Albizzia procera* .	Kurseong Division, Bengal.	Trees girdled for 1 year, then felled and converted, and seasoned for 1 year and 9 months.	43	..	65	28	..	9*	Do.
Ditto . .	Do. .	Trees girdled for 2 years, then felled and converted, and seasoned for 9 months.	50	..	78	22	..	..	Do.
Ditto . .	Do. .	Trees girdled for 2 years and 9 months, converted and then inspected.	31	..	72	22	..	6	Do.
Ditto . .	Do. .	Log seasoned in water for 5 months, on land for 13 months, and then converted.	38	26·27	84	16	..	..	Do.
Ditto .	Do. .	Seasoned in log for 12 months, with ends tarred, then converted and seasoned in plank for 21 months.	31	27·78	97	3	..	..	Do
Ditto . .	Do. .	Seasoned in log for 18 months, with ends tarred, then converted and seasoned in plank for 15 months.	42	..	71	29	..	2*	Do.
Ditto . .	Do. .	Seasoned in log for 2 years and 6 months, with ends tarred, converted and seasoned in plank for 3 months.	42	..	81	19	..	..	Do.
Ditto . .	Do. .	Seasoned in log for 1 year, with ends treated with Loracine, then converted and inspected after 21 months.	17	..	83	17	..	..	Do.

Ditto . .	Do. .	Seasoned in log for 18 months with ends treated with Loracine, then converted and inspected after 15 months.	24	32·64	84	12	..	4	Do.
Ditto . .	Do. .	Seasoned in log for 2½ years, with ends treated with Loracine, then converted and inspected after 3 months.	23	..	96	4	..	..	Do.
Ditto . .	Do. .	Converted green and seasoned in plank for 2 years and 9 months.	28	25·23	100	..	..	..	Very good.
(4) *Anthocephalus Cadamba.*	Do. .	One set of trees girdled for 8 months, another for a year and in both cases converted material stored so as to make up a period of 2 years and 9 months.	..	..	..	..	..	..	That portion of the timber, which, when stacked was protected by that above from excessive moisture is sound, the rest absolutely rotten.
Ditto . .	Do. .	Seasoned in log for 18 months, with bark off, and in plank for 15 months.	..	..	..	..	..	..	All rotten, fungus attack.
Ditto . .	Do. .	Converted green and seasoned for 2 years and 9 months.	..	..	..	..	..	..	Do.
Ditto . .	Do. .	Seasoned in log immersed in water for 3½ months, on land for 14½ months, then converted and seasoned in planks for 15 months.	..	..	..	..	..	..	Do.
Ditto . .	Do. .	Seasoned in log for varying periods, with ends tarred and then converted and planks stacked.	..	..	..	..	..	..	Do.
Ditto . .	Do. .	Seasoned in log for varying periods, with ends treated with Loracine, then converted and planks stacked.	..	..	..	..	..	..	Do.
(5) *Artocarpus Chaplasha.*	Do. .	Seasoned in the open in log for 18 months, with bark off, converted and seasoned in planks for 15 months.	52	18·31	71	25	6*	..	Very fair.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	PERCENTAGE. Sound.	Badly cracked.	Badly warped.	Insect attack.	REMARKS.
(5) *Artocarpus Chaplasha*—contd.	Kurseong Division, Bengal.	Converted green and seasoned for 2 years and 9 months.	24	..	71	21	8	..	Very fair.
Ditto . .	Do. .	Seasoned in log and immersed in water for 5 months, on land for 13 months, converted and seasoned in planks for 15 months.	15	19·81	60	13	40*	..	Fair.
Ditto . .	Do. .	Trees girdled for one year, felled and converted and planks seasoned for 1 year and 9 months.	85	..	73	21	6*	1	Good.
Ditto . .	Do. .	Trees girdled for 18 months, felled and converted and planks seasoned for 15 months.	99	18·80	73	26	1	2*	Do.
Ditto . .	Do. .	Trees girdled for 2 years and 8 months, felled and converted, and planks seasoned for 1 month.	147	..	73	26	..	2*	Do.
Ditto . .	Do. .	Seasoned in log for one year, ends tarred, converted and seasoned in planks for 1 year 9 months.	12	..	42	58	..	..	Rather poor logs originally.
Ditto . .	Do. .	Seasoned in log for 18 months, ends tarred, converted and seasoned in plank for 15 months.	17	..	54	34	..	12	Poor.
Ditto . .	Do. .	Seasoned in log for 2 years and 5 months, ends tarred, converted and seasoned in plank for 4 months.	15	..	66	34	..	..	Fair.

Ditto . .	Do. .	Seasoned in log for 1 year, and smeared with Loracine, converted and seasoned in plank for 1 year and 9 months.	..	..	..	..	..	..	Log full of sapwood, experiment cancelled.
Ditto . .	Do. .	Similar experiments as elsewhere with Loracine.	..	..	..	..	..	..	Do.
Ditto . .	Chittagong Division, Bengal.	Seasoned in log, with bark off, for 24 months, then converted and seasoned in plank for 12 months.	17	17·57	100	..	..	..	Good, though about 33 per cent. slightly split.
Ditto . .	Do. .	Converted green and seasoned in plank for 36 months.	18	19·76	100	..	..	..	Good, but all slightly split.
Ditto . .	Do. .	Seasoned in log, immersed in water for 3 to 6 months, on land for 18 months, then converted and seasoned in plank for 12 months.	66	From 13·12 to 13·73	92	8	..	..	Very good, though discoloured.
Ditto . .	Do. .	Seasoned in log, ends treated with Loracine, bark on, for 12 to 21 months, and seasoned in plank for 14 to 24 months.	13	From 13·97 to 17·51	100	..	..	..	Very good, though some slight cracking.
Ditto . .	Do. .	Seasoned in log, ends treated with cowdung and mud, bark on, for 12 to 22 months, and seasoned in plank for 14 to 24 months.	19	From 13·87 to 16·64	84	16	..	..	Good.
Ditto . .	Do. .	Trees girdled for 12 months, then felled and converted and seasoned in plank for 24 months.	**36**	From 14·14 to **17·37**	**92**	**8**	..	..	Very good all through.
(6) *Bassia latifolia* .	Bahraich Division, United Provinces.	Seasoned in log immersed in water for 4 months, then seasoned on land, converted and seasoned in the plank, so as to bring the total period up to 2 years and six months.	21	From 10·94 to 15·93	29	71	..	..	Poor.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Sound.	Percentage. Badly cracked.	Badly warped.	Insect attack.	Remarks.
(6) *Bassia latifolia*—contd.	Bahraich Division, United Provinces.	Seasoned in log, without bark, under shade for 18 months, and as planks for 12 months.	23	From 10·78 to 14·75	48	52	4	..	Poor, much surface cracking.
Ditto	Do.	Seasoned in log, with bark, under shade, for 18 months, and as planks for 12 months.	25	From 11·64 to 17·50	40	56	4	..	Poor.
Ditto	Do.	Green conversion, planks seasoned in shade and weighted, for 2 years and 6 months.	**47**	From 10·34 to **10·66**	**83**	**15**	**2**	..	Good, though many surface cracks.
(7) *Bassia longifolia*	N. D. Kanara, Bombay.	Seasoned in log from 15 to 26 months, then converted into planks and seasoned for from 10 to 21 months.	28	16·11	36	64	..	7*	Poor.
Ditto	Do.	Green conversion and planks seasoned for 3 years.	**16**	**18·97**	**69**	**31**	..	..	Good, though period of seasoning is too long.
Ditto	Do.	Logs roughly squared and seasoned for 15 to 26 months, converted into planks and seasoned from 10 to 21 months.	25	..	8	92	..	..	Very poor.
Ditto	Do.	Seasoned in log with ends treated with Loracine, for from 15 to 26 months, converted into planks and seasoned for from 10 to 21 months.	35	..	6	94	..	..	Ditto.

Ditto . .	Do. .	soned in log with ends treated with mud and cow-dung, for from 15 to 26 months, converted into planks and seasoned for from 10 to 21 months.	28	..	57	43	..	..	Fair.
Ditto .	Do. .	Seasoned in log with ends treated with tar, for from 15 to 26 months, converted into planks and seasoned for from 10 to 21 months.	20	18·13	15	85	..	..	Very poor.
Ditto . .	Do. .	Seasoned in log with cut to centre, for from 15 to 26 months, converted into planks and seasoned for 10 to 21 months.	25	..	35	65	..	..	Poor.
(8) *Bombax malabaricum*	Ramnagar Division, United Provinces.	Planks converted from green logs, immersed in running water for 2 months, stacked in shade and seasoned for 2 years.	10	9·31	50	50	..	..	Fair.
Ditto . .	Siwalik Division, United Provinces.	Planks converted from green logs, immersed in running water for 4 weeks and dried in shed for 19 months.	**14**	**11·08**	**93**	**7**	..	..	Very good.
Ditto . .	Do. .	Logs immersed for 4 months in still water, dried for 13 months in log, converted and dried in plank, in shed for 3 months.	15	15·01	..	53	..	..	Very poor.
Ditto . .	Do. .	As above, but immersed in running water for 4 months.	16	12·30	..	75	..	..	Poor.
Ditto . .	Do. .	Seasoned in log for 17 months, converted and seasoned in plank for 3 months.	25	19·22	..	44	..	..	Riddled by borers, very poor.
Ditto . .	Do. .	Planks converted from green logs and seasoned for 20 months in shed.	15	14·43	..	60	..	..	Very poor.

* NOTE.—Some or all of those planks which are attacked by insects are also either cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(9) *Cedrela Toona*	Kurseong Division, Bengal.	Logs seasoned with bark off, in open for 18 months, then converted and planks seasoned for 15 months.	36	27·60	47	53	..	..	Fair.
Ditto	Do.	Girdled for one year, then felled and converted and seasoned in plank for 21 months.	**231**	**22·86**	**91**	**8**	1	..	Very good.
Ditto	Do.	Girdled for 18 months, then felled and converted and seasoned in plank for 15 months.	159	..	82	16	..	2	Do.
Ditto	Do.	Girdled for 31 months, then felled and converted and seasoned in plank for 2 months.	241	..	65	35	..	..	Good.
Ditto	Do.	Seasoned in log immersed in water for 4½ months, on land for 13½ months, then converted and seasoned in plank for 15 months.	67	28·00	40	60	..	2*	Poor, much fungus attack.
Ditto	Do.	Seasoned in log for one year, ends tarred, then converted and seasoned in plank for 21 months.	17	..	59	41	..	6*	Fair.
Ditto	Do.	Seasoned in log for 18 months, ends tarred, then converted and seasoned in plank for 15 months.	30	..	67	33	..	..	Very poor.
Ditto	Do.	Seasoned in log for 2 years and 7 months, ends tarred, then converted and seasoned for 2 months.	34	42·86	85	15	..	..	Good, by still far from seasoned having 42·8 per cent of moisture.

Ditto	Do.	Seasoned in log for 1 year, ends treated with Loracine, converted and seasoned in plank for 21 months.	22	..	64	36	..	..	Good.
Ditto	Do.	Seasoned in log for 18 months, ends treated with Loracine, converted and seasoned in plank for 15 months.	20	22·90	90	10	..	..	Very good.
Ditto	Do.	Seasoned in log for 30 months, ends treated with Loracine, converted and seasoned in plank for 3 months.	40	..	65	35	..	..	Good.
Ditto	Do.	Converted green, planks seasoned for 2 years and 9 months.	51	..	39	50	20*	..	Poor.
(10) *Dalbergia latifolia*	N. D. Kanara, Bombay.	Logs seasoned with bark on, in the open, for from 15 to 26 months, then converted and seasoned in plank for from 10 to 21 months.	27	13·82	67	33	..	..	Cracks due to original defects in the centre of the timber.
Ditto	Do.	Seasoned in log, with sides roughly squared, for from 15 to 26 months, then converted into planks and seasoned for from 10 to 21 months.	24	..	100	..	..	..	Very good.
Ditto	Do.	Seasoned in log, with a cut to centre, for from 15 to 21 months, then converted into planks and seasoned for from 10 to 21 months.	19	..	90	10	..	..	Cracks due to original defects in the centre of the timber.
Ditto	Do.	Planks converted from green logs and seasoned in the open for 3 years.	23	14·82	78	22	..	..	Do.
Ditto	Do.	Seasoned in logs, with ends treated with Loracine, for from 15 to 26 months, then converted and seasoned in plank for from 10 to 21 months.	19	..	74	26	..	..	Do.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(10) *Dalbergia latifolia*—contd.	N. D. Kanara, Bombay.	Seasoned in log, with ends treated with cowdung and mud, for from 15 to 26 months, then converted and seasoned in plank for from 10 to 21 months.	27	..	93	7	..	..	Cracks due to original defects in the centre of the timber.
Ditto . .	Do. .	Seasoned in log, with ends treated with tar, for from 15 to 26 months, then converted and seasoned in plank for from 10 to 21 months.	**26**	**12·09**	**100**	..	..	..	..
(11) *Dalbergia Sissoo* .	Ramnagar Division, United Provinces.	Logs seasoned in the shade for 18 months, then converted and seasoned in plank for 9 months.	53	From 10·07 to 11·33	89	11	..	..	Good.
Ditto . .	Do. .	Logs immersed in running water for 4 months, seasoned on land and in shade 14 months, then converted and seasoned in plank for 9 months.	56	From 9·17 to 13·85	95	5	..	..	Do.
Ditto	Lahore Division, Punjab.	Seasoned in log, with bark on, for 23 months, then converted and seasoned in plank for 6 months.	12	From 9·87 to 12·15	75	25	..	..	Do.
Ditto .	Do. .	Seasoned in log, with bark off, for 23 months, then converted and seasoned in plank for 6 months.	17	From 8·87 to 10·86	59	41	..	..	Fair.
Ditto .	Do. .	Scantlings cut from green logs, and seasoned for 2 years and 6 months.	27	From 9·60 to 12·00	82	18	..	..	Good.

Ditto . .	Do. .	Trees girdled for 14 months, then felled and converted and seasoned in plank for 15 months.	25	From 8·48 to 9·52	75	20	10*	..	Do.
Ditto . .	Do. .	Trees girdled for 18 months, then felled and converted and seasoned in plank for 12 months.	**22**	**11·47**	**100**	..	..	..	Very good.
Ditto . .	Do. .	Trees girdled for 23 months, then felled and converted and seasoned in plank for 7 months.	14	14·86	89	21	..	..	Good.
Ditto . .	Do. .	Seasoned in log, with ends treated with Loracine, for from 12 to 17 months, and seasoned in plank for from 5 to 10 months.	32	From 9·46 to 12·30	69	31	..	..	Do.
Ditto . .	Do. .	Seasoned in log, with ends treated with cowdung and mud for from 18 to 23 months, then converted and seasoned in plank for 5 to 10 months.	49	From 9·37 to 13·99	59	41	2*	..	Fair.
Ditto . .	Do. .	Seasoned in log, with ends treated with tar, for from 11 to 23 months, then converted and seasoned in plank for from 5 to 17 months.	53	From 9·26 to 14·16	68	32	..	..	Do.
(12) *Dillenia pentagyna*	Kurseong Division, Bengal.	Seasoned in the open, in the log, for 18 months, with bark off, converted and seasoned in the plank for 15 months.	40	..	..	..	..	..	Both planks and rafters all rotten.
Ditto . .	Do. .	Planks converted from green logs and seasoned for 2 years and 9 months.	9	..	..	..	..	..	Ditto.
Ditto . .	Do. .	Seasoned in log, and immersed in water for 4 months, on land for 14 months, converted and seasoned in the plank for 15 months.	27	..	56	44	..	4*	Many planks attacked by fungus.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	PERCENTAGE. Sound.	Badly cracked.	Badly warped.	Insect attack.	REMARKS.
(12) *Dillenia pentagyna*—contd.	Kurseong Division, Bengal.	Trees girdled for 12 months, felled and converted into planks and seasoned for 21 months.	36	38·51	58	42	..	..	Slight fungus attack.
Ditto . .	Do. .	Trees girdled for 21 months, felled and converted into planks and seasoned for 12 months.	78	30·18	86	14	..	..	No fungus or insect attack.
Ditto . .	Do. .	Trees girdled for 30 months, felled and converted into planks and seasoned for 3 months.	38	..	97	..	..	3	Material still containing a high percentage of moisture.
Ditto . .	Do. .	Seasoned in log, with ends tarred, for periods varying from 12 to 33 months and then converted.	..	..	..	..	..	..	Both planks and rafters all rotten.
Ditto . .	Do. .	Seasoned in log, with ends treated with Loracine, for periods varying from 12 to 33 months and then converted.	..	..	..	..	..	..	Ditto.
(13) *Diospyros Melanoxylon.*	S. Chanda Division, Central Provinces.	Felled in January, seasoned in log, in shed, with bark on, for 22 months, converted and seasoned in plank for 13 months.	20	..	10	90	..	25*	Very poor.
Ditto . .	Do. .	Felled in January, treated as above, but with bark off.	17	..	59	41	..	6*	Fair.
Ditto . .	Do. .	Felled in April, seasoned in log, in shed, with bark on, for 22 months, converted and seasoned in plank for 10 months.	13	..	15	85	..	38*	Very poor.

Ditto . .	Do. .	Felled in April, treated as above, but with bark off.	18	..	11	89	..	..	Do.
Ditto . .	Do. .	Felled in August, seasoned in log, in shed, with bark on, for 18 months, converted and seasoned in plank for 10 months.	11	14·90	..	100	..	36*	Do.
Ditto . .	Do. .	Felled in August, treated as above, but with bark off.	10	..	60	40	..	..	Fair.
Ditto . .	Do. .	Log seasoned in water for 3 months; on land, in shed, for 18 months; then converted and seasoned in plank for 14 months.	36	16·42	..	69	8*	75*	Very poor.
Ditto . .	Do. .	Converted from green logs and seasoned, in shed, for 11 months.	15	15·76	60	40	..	7*	Fair.
Ditto . .	Do. .	Converted green, scantlings seasoned in water for 5 months and in shed for 6 months.	7	17·92	72	28	..	..	Good.
Ditto . .	Do. .	Converted green, scantlings seasoned in water for 9 months, and in shed for 2 months.	8	15·44	62	38	..	..	Very fair.
Ditto . .	Do. .	Trees girdled for 23 months, felled and converted and seasoned in shed for 12 months.	**19**	**17·23**	**84**	**16**	..	..	Very good.
(14) *Duabanga sonneratioides.*	Kurseong Division, Bengal.	Logs seasoned with bark off, in open, for 18 months, then converted and seasoned in plank for 15 months.	20	14·74	60	40	5*	..	Fair.
Ditto . .	Do. .	Girdled for 12 months, then felled and converted and seasoned in plank for 21 months.	113	..	58	42	..	..	Do.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(13) *Duabanga sonneratioides.*	Kurseong Division, Bengal.	Girdled for 24 months, then felled and converted, and seasoned in plank for 9 months.	**194**	**20·68**	**78**	**21**	**2***	..	Good.
Ditto . .	Do. .	Girdled for 33 months, then felled and converted and inspected at once.	138	Still very wet.	59	9	..	22	Fair, much insect attack due to standing girdled too long.
Ditto . .	Do. .	Seasoned in log, immersed in water for 4 months, on land for 14 months, then converted and seasoned in plank for 15 months.	24	44·40	75	21	..	4	Fair, showing signs of rotting.
Ditto . .	Do. .	Seasoned in log for 18 months, ends tarred, then converted and seasoned in plank for 21 months.	17	..	53	35	..	18*	Do.
Ditto . .	Do. .	Seasoned in log for 18 months, ends tarred, then converted and seasoned in plank for 15 months.	30	45·68	80	17	..	3	Planks much attacked by fungus.
Ditto . .	Do. .	Seasoned in log for 26 months, ends tarred, then converted and seasoned in plank for 7 months.	25	..	40	60	..	..	Do.
Ditto . .	Do. .	Seasoned in log for 12 months, ends treated with Loracine, then converted and seasoned in plank for 21 months.	..	..	..	..	..	..	All attacked by fungus and rotten.
Ditto . .	Do. .	Seasoned in log for 18 months, ends treated with Loracine, then converted and seasoned in planks for 15 months.	16	..	25	63	..	19*	Commencing to rot.

Ditto . .	Do. .	Seasoned in log for 26 months, ends treated with Loracine, converted and seasoned in plank for 7 months.	22	..	67	23	..	..	Fair.
Ditto . .	Do. .	Converted green, and seasoned in plank for 33 months.	21	22·42	38	62	..	..	Fair, no rot.
(15) *Grewia tiliaefolia* .	N. D. Kanara, Bombay.	Natural seasoning in the log, with bark on, for from 15 to 26 months, then converted into planks and seasoned for from 10 to 21 months.	16	16·90	25	69	..	25*	Poor.
Ditto . .	Do. .	Logs rough squared and seasoned for from 15 to 26 months, then converted and seasoned in plank for from 10 to 21 months.	21	..	19	..	..	81	Do.
Ditto . .	Do. .	Seasoned in log with cut to centre, for from 15 to 26 months, then converted and seasoned in plank for from 10 to 21 months.	32	..	44	47	..	16*	Fair.
Ditto . .	Do. .	Converted green and planks seasoned for 36 months.	**20**	**17·85**	**50**	**50**	..	..	Good, but timber left too long exposed.
Ditto . .	Do. .	Seasoned in log with ends treated with Loracine, for from 15 to 26 months, converted and seasoned in plank for from 10 to 21 months.	18	..	28	72	..	8*	Poor.
Ditto . .	Do. .	Seasoned in log, with ends treated with mud and cow-dung, for from 15 to 26 months, converted and seasoned in plank for from 10 to 21 months.	24	..	30	66	..	4	Do.
Ditto . .	Do. .	Seasoned in log, with ends tarred, for from 15 to 26 months, converted and seasoned in plank for from 10 to 21 months.	24	17·79	58	42	..	..	Fair, though slight splitting excessive.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	PERCENTAGE.				REMARKS.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(16) *Lagerstrœmia Flos-Reginæ.*	Chittagong Division, Bengal.	Seasoned in log, with bark off, for 24 months, then converted and seasoned in plank for 12 months.	19	18·56	42	58	..	..	Poor to fair.
Ditto . .	Do. .	Converted green and seasoned in plank for 36 months.	**18**	**15·12**	**100**	..	..	..	Very good, though slightly under 50 per cent. are very slightly split.
Ditto . .	Do. .	Seasoned in log, immersed in water for from 3 to 6 months, on land for 18 months, then converted and seasoned in plank for 12 months.	59	16·77	47	53	..	..	Fair to good.
Ditto . .	Do. .	Seasoned in log, ends treated with Loracine, bark on, for 12 to 22 months, and seasoned in plank for 14 to 24 months.	21	From 17·23 to 18·31	57	43	..	..	Good.
Ditto . .	Do. .	Seasoned in log, ends treated with cowdung and mud, bark on, for 12 to 22 months, and seasoned in plank for 14 to 24 months.	22	From 15·68 to 20·28	45	55	..	..	Fair to good.
Ditto . .	Do. .	Trees girdled for 12 months, then felled and converted and seasoned in plank for 24 months.	**29**	From 15·31 to **17·40**	**90**	**10**	..	..	Very good, and even better than green conversion, as 90 per cent. have no signs whatsoever of cracks.
Ditto . .	Do. .	Trees girdled for 24 months, then felled and converted and seasoned in plank for 12 months.	**24**	From 15·70 to **17·28**	**92**	**8**	..	..	Do.

(17) ***Lagerstrœmia microcarpa.***	N. D. Kanara, Bombay.	Seasoned in the log, with bark on for 15 to 26 months, converted and seasoned in plank for 10 to 21 months.	29	16·22	41	52	3*	14*	Poor to fair.
Ditto . .	W. D. Kanara, Bombay.	Seasoned in log, in shade, for 21 to 27 months, then converted and seasoned in plank or scantling for 12 to 18 months.	43	..	16	39	7*	77*	Some insect attack and badly cracked. Poor.
Ditto . .	N. D. Kanara, Bombay.	Seasoned in log, with sides rough squared, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	22	..	45	36	4*	18	Poor to fair.
Ditto . .	Do. .	Seasoned in log with cut to centre, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	22	..	..	100	..	18*	Very poor.
Ditto . .	Do. .	Planks converted from green logs and seasoned in the open for 3 years.	17	18·56	48	52	..	..	Fair.
Ditto . .	Do. .	Seasoned in log, with ends treated with Loracine, bark on, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	21	..	14	86	..	..	Very poor.
Ditto . .	Do. .	Seasoned in log, with ends treated with cowdung and mud, bark on, for 15 to 26 months, then converted and seasoned in the plank for 10 to 21 months.	28	..	29	68	..	36*	Poor.
Ditto . .	Do. .	Seasoned in log, with ends tarred, bark on, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	**21**	**16·89**	**71**	**29**	..	7*	Good.
Ditto . .	W. D. Kanara, Bombay.	Buried in mud, in tidal creek, for one year, seasoned in a shed for 9 months, converted and seasoned in plank for 18 months.	26	..	58	11	..	35*	A good lot of timber, cracking slight, the most serious damage is from borers.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(17) *Lagerstrœmia microcarpa*—contd.	W. D. Kanara, Bombay.	As above, but seasoned in log on land foı 15 months and in plank for 12 months.	60	..	5	20	6	95*	Heavily attacked by insects, otherwise timber in good condition.
(18) *Lagerstrœmia parviflora.*	Kurseong Division, Bengal.	Seasoned in the open in log, with bark oft, for 10 months, converted and seasoned in plank for 15 months.	29	29·50	59	41	..	..	Fair.
Ditto . .	Do. .	Planks converted from green logs, and seasoned for 33 months.	13	27·91	69	31	..	..	Good, though a good deal of fine surface cracking.
Ditto . .	Do. .	Seasoned in log, immersed in water for 5 months, on land for 13 months, then converted and seasoned in plank for 15 months.	23	26·91	74	22	..	4	Do.
Ditto . .	Do. .	Trees girdled for 12 months, then felled and converted and seasoned in plank for 31 months.	**68**	**27·36**	**90**	**7**	..	**6***	Very good, surface cracking not serious.
Ditto . .	Do. .	Trees girdled for 18 months, then felled and converted and seasoned in plank for 15 months.	58	..	71	22	..	10*	Good.
Ditto . .	Do. .	Trees girdled for 30 months, then felled and converted and seasoned in plank for 3 months.	69	..	48	13	..	48*	Heavily attacked by large borers.
Ditto . .	Do. .	Seasoned in log for 12 months, ends tarred, then converted and seasoned in plank for 21 months.	12	..	8	66	..	33*	Very poor.

Ditto .	Do. .	Seasoned in log for 18 months, ends tarred, then converted and seasoned in plank for 15 months.	19	29·11	53	47	..	..	Poor to fair.
Ditto . .	Do. .	Seasoned in log for 30 months, ends tarred, then converted and seasoned in plank for 3 months.	15	..	53	33	..	33*	Do.
Ditto . .	Do. .	Seasoned in log for 12 months, ends treated with Loracine, then converted and seasoned in plank for 21 months.	16	38·50	69	31	..	..	Very fair.
Ditto . .	Do. .	Seasoned in log for 18 months, ends treated with Loracine, then converted and seasoned in plank for 15 months.	15	..	80	20	..	..	Good.
Ditto . .	Do. .	Seasoned in log for 30 months, ends treated with Loracine, then converted and seasoned in plank for 3 months.	16	..	75	25	..	..	Do.
Ditto . .	S. Chanda, Central Provinces.	Felled in January, seasoned in log, in shed, with bark on, for 21 months, then converted and seasoned in plank for 14 months.	9	..	..	100	10*	..	Very poor.
Ditto . .	Do. .	Felled in January, treated as above, but with bark off.	10	..	20	80	..	..	Do.
Ditto . .	Do. .	Felled in April, seasoned in log, in shed, with bark on, for 18 months, then converted and seasoned in plank for 14 months.	11	..	9	91	..	..	Do.
Ditto . .	Do. .	Felled in April, treated as above, but with bark off.	..	..	..	..	..	..	Logs heavily split and therefore not converted.
Ditto . .	Do. .	Felled in August, seasoned in log, in shed, with bark on, for 15 months, then converted and seasoned in plank for 9 months and 14 months.	9	..	56	44	..	..	Fair.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	PERCENTAGE.				REMARKS.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(18) *Lagerstrœmia parviflora*—contd.	S. Chanda, Central Provinces.	Felled in August and treated as above, but with bark off.	5	..	40	60	..	..	Poor to fair.
Ditto . .	Do. .	Trees girdled for 22 months, then felled and converted and seasoned in plank for 12 months.	8	21·10	62	38	..	..	Good deal cracking, due to original defect.
Ditto . .	Do. .	Log seasoned in water for 3 months, in shed, on land for 17 months, then converted and seasoned in plank for 14 months.	13	17·55	15	77	..	8	Very poor.
Ditto . .	Do. .	Converted green and seasoned in water for 5 to 9 months and seasoned in shed for 2 to 6 months.	**9**	**16·90**	**89**	**11**	..	..	Good.
Ditto . .	Do. .	Converted green and seasoned in shed for 11 months.	10	27·48	80	20	..	..	Do.
(19) *Machilus doratissima.*	Darjeeling Division, Bengal.	Seasoned in open, in log for 18 months, then converted and seasoned in plank for 18 months.	47	30·88	96	2	..	2	Good, though slight warp is recorded in many instances.
Ditto . .	Do. .	Logs converted green and planks seasoned for 33 months.	23	43·62	..	..	..	..	Timber chiefly rotten and very much discoloured.
Ditto . .	Do. .	Seasoned in log, immersed in water for 5 months, on land for 12 months, then converted and seasoned in plank for 18 months.	34	53·44	56	3	..	44*	At the time of inspection, the insect attack was not severe but was developing.

Ditto . .	Do. .	Trees girdled for 12 months, then felled and converted and seasoned in plank for 24 months.	**194**	..	**93**	7	..	..	Very good.
Ditto . .	Do. .	Trees girdled for 18 months, then felled and seasoned in plank for 18 months.	**130**	**27·29**	**92**	8	..	..	Very good, colour even better than that of 12 months girdled timber.
Ditto . .	Do. .	Seasoned in log for 12 months, ends treated with Loracine, then converted and seasoned in plank for 18 months.	16	41·94	31	19	..	56*	Poor.
Ditto . .	Do. .	Seasoned in log for 18 months, ends treated with Loracine, then converted and seasoned in plank for 12 months.	21	..	75	5	..	20	Fair.
Ditto . .	Do. .	Seasoned in log for 24 months, ends treated with Loracine, then converted and seasoned in plank for 6 months.	21	..	50	5	..	15	50 per cent of timber much attacked by fungus and rotten.
(20) *Michelia Champaca*	Kurseong Division, Bengal.	Seasoned in open, in log, bark off, for 18 months, then converted and seasoned in plank for 15 months.	50	28·20	50	26	..	24	Poor, a good deal of fungus attack.
Ditto . .	Do. .	Logs converted green and planks seasoned for 33 months.	21	23·42	28	62	..	14*	Poor.
Ditto . .	Do. .	Seasoned in log, immersed in water for 4 months, on land for 14 months, then converted and seasoned in plank for 15 months.	35	24·56	57	43	..	..	Fair.
Ditto . .	Do. .	Trees girdled for 12 months, then felled and converted and seasoned in plank for 21 months.	**84**	..	**73**	**25**	..	**2**	Good.
Ditto . .	Do. .	Trees girdled for 21 months, then felled and converted and seasoned in plank for 12 months.	**144**	**31·10**	**72**	**28**	..	..	Do.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(20) *Michelia Champaca*—contd.	Kurseong Division, Bengal.	Trees girdled for 30 months, then felled and converted and seasoned in plank for three months.	**71**	..	**84**	**16**	..	..	Very good, but still very green.
Ditto . .	Do. .	Seasoned in log for 12 months, ends tarred, then converted and seasoned in plank for 21 months.	16	..	38	62	..	..	Poor, also fungus attack.
Ditto . .	Do. .	Seasoned in log for 18 months, ends tarred, then converted, and seasoned in plank for 15 months.	25	26·26	64	28	..	8	Fair, a good deal of fungus attack.
Ditto . .	Do. .	Seasoned in log for 30 months, ends tarred, then converted and seasoned in plank for 3 months.	34	..	44	21	..	35	Poor, some fungus attack.
Ditto . .	Do. .	Seasoned in log for 12 months, ends treated with Loracine, then converted and seasoned in plank for 21 months.	12	..	25	17	..	..	75 per cent. attacked by fungus.
Ditto . .	Do. .	Seasoned in log for 18 months, ends treated with Loracine, then converted and seasoned in plank for 15 months.	13	20·18	50	31	..	..	50 per cent. of the timber attacked by fungus.
Ditto . .	Do. .	Seasoned in log for 30 months, ends treated with Loracine, then converted and seasoned in plank for 3 months.	10	..	50	10	..	..	Do.
(21) *Morus indica* .	Lahore Division, Punjab.	Logs seasoned in shade, with bark on, for 12 to 24 months, then converted and seasoned in plank for 6 to 18 months.	18	From 10·55 to 11·06	55	28*	44*	..	Poor, much warped, a good deal of surface cracking.

Ditto . .	Do. .	Logs seasoned in shade, with bark off, for 18 months, then converted and seasoned in plank for 12 months.	22	From 10·81 to 14·17	32	23*	64*	..	Poor, much warped.
Ditto . .	Do. .	Scantlings cut from green logs, and seasoned in shade for 30 months.	19	From 8·24 to 11·96	32	21	53*	..	Do.
Ditto . .	Do. .	Trees girdled for 8 months, then converted and seasoned in scantling for 22 months.	**12**	**16·99**	**83**	**17**	..	..	Good, though slight warp noticed in a few scantlings.
Ditto . .	Do. .	Trees girdled for 12 months, then converted and seasoned in scantlings for 18 months.	**8**	**11·59**	**93**	**7**	..	..	Good, though slight warp and surface cracking noticeable.
Ditto . .	Do. .	Trees girdled for 18 months, then converted and seasoned in scantlings for 12 months.	12	From 12·11 to 16·02	75	..	25	..	Do.
Ditto . .	Do. .	Seasoned in log, with ends treated with Loracine, for 9 to 17 months, then converted and seasoned in scantling for 13 to 21 months.	20	From 10·75 to 19·94	80	5*	20*	..	Good, very little serious warping.
Ditto . .	Do. .	Seasoned in log, with ends treated with cowdung and mud, for 13 to 24 months, then converted and seasoned in scantling for 6 to 17 months.	34	From 7·70 to 16·18	41	23*	50*	..	Poor, much warped.
Ditto .	Do. .	Seasoned in log, with ends treated with tar, for 12 to 23 months, then converted and seasoned in scantling for 7 to 18 months.	26	From 8·83 to 14·68	39	8	61	..	Do.
(22) *Ougeinia dalbergioides.*	N. D. Kanara, Bombay.	Logs seasoned with bark on, in open, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	19	15·29	84	..	..	16	Good.

*NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(22) *Ougeinia dalbergioides*—contd.	N. D. Kanara, Bombay.	Seasoned in log, with sides rough squared, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	**19**	..	**95**	**5**	..	..	Very good.
Ditto .	Do. .	Seasoned in log, with a cut to centre, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	27	..	74	4	..	22	Good.
Ditto .	Do. .	Planks converted from green logs, and seasoned in open for 36 months.	**20**	**17·62**	**95**	**5**	..	..	Very good.
Ditto .	Do. .	Seasoned in log, with ends treated with Loracine, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	23	..	80	8	12	..	Good.
Ditto .	Do. .	Seasoned in log, with ends treated with cowdung and mud, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	29	..	70	27	..	3	Good ; one log originally very faulty.
Ditto .	Do. .	Seasoned in log, with ends tarred, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	23	17·13	87	..	..	13	Good.
Ditto .	S. Chanda Division, Central Provinces.	Felled in January, seasoned in log, in shed, with bark on, for 22 months, then converted and seasoned in plank for 13 months.	15	..	60	..	..	40	Fair, a good deal of surface cracking.

Ditto	Do.	Felled in January, treated as above, but with bark off.	**11**	..	**91**	**9**	..	..	Very good, though a number of planks slightly warped.
Ditto	Do.	Felled in April, seasoned in log, in shed, with bark on, for 19 months, then converted and seasoned in plank for 13 months.	7	..	..	14	..	100*	Very poor.
Ditto	Do.	Felled in April, treated as above, but with bark off.	7	..	58	14	28	..	Fair.
Ditto	Do.	Felled in August, seasoned in log, in shed, with bark on for 15 months, then converted and seasoned in plank for 13 months.	6	..	51	16	..	33	Fair.
Ditto	Do.	Felled in August, treated as above, but with bark off.	**9**	**16·44**	**100**	..	..	..	Very good, though several planks are very slightly split.
Ditto	Do.	Logs immersed in water for 3 months, seasoned on land for 17 months, then converted and seasoned in plank for 15 months.	23	17·74	87	13	..	..	Good.
Ditto	Do.	Trees girdled for 21 months, then felled and converted and seasoned in plank for 13 months.	10	18·38	40	..	..	60	Fair.
(23) *Pinus longifolia*	Rawalpindi Division, Punjab.	Seasoned in the log, with bark off, for 12 months, then converted and seasoned in plank or rafter for 10 months.	6	13·17	34	16	66	..	Poor.
Ditto	Do.	Seasoned in log, with bark off, for 18 months, then converted and seasoned in plank or rafter for 12 months.	8	From 13·29 to 14·09	100	..	..	..	Fair to good, all slightly cracked.
Ditto	Do.	Seasoned in log, with bark off, for 24 months, then converted and seasoned in plank or rafter for 6 months.	12	From 11·85 to 14·03	34	17	16	33	Fair to good, and some slightly warped.

*NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(23) *Pinus longifolia* —contd.	Rawalpindi Division, Punjab.	Planks and rafters converted from green timber, and seasoned for 30 months.	**46**	From 12·85 to **13·07**	**77**	**19**	**4**	..	Good, though a good deal of surface cracking and slight warping.
Ditto	Do.	Timber seasoned in log for 12 to 24 months, with ends treated with Loracine, then converted into B. G. sleepers fitted with "S" clamps fixed to ends, and seasoned for 6 to 18 months.	4	15·51	75	..	25	..	Good, slightly warped.
Ditto	Do.	Timber seasoned in log for 12 to 24 months, with ends treated with cowdung and mud, then converted into B.G. sleepers, fitted with "S" clamps on ends, and seasoned for 6 to 18 months.	4	18·91	75	..	25	..	Good.
Ditto	Do.	Timbers seasoned in log for 12 to 24 months, with ends tarred, then converted into B. G. sleepers, fitted with "S" clamps, and seasoned for 6 to 18 months.	4	17·90	75	..	25	..	Do.
Ditto	Kangra Division, Punjab.	Seasoned in log, with bark off, for 12 months, then converted and seasoned in scantlings or sleepers for 18 months.	17	9·33	6	35	..	94*	Poor, due to insect attack.
Ditto	Do.	Seasoned in log, with bark off, for 18 months, then converted and seasoned in scantlings or sleepers for 12 months.	17	10·45	..	..	..	100	Do.

Ditto .	Do. .	Seasoned in log, with bark off for 24 months, then converted and seasoned in scantlings or sleepers for 6 months.	12	12·05	..	..	..	100	Do.
Ditto .	Do. .	B. G. sleepers and rafters converted from green logs and seasoned for 30 months.	**140**	From 9·24 to **11·95**	**89**	**5**	**6**	..	Very good.
Ditto .	Do. .	Timber seasoned in log for 12 to 24 months, ends treated with Loracine, then converted into planks, rafters and B. G. sleepers, and seasoned for 6 to 18 months.	53	From 9·96 to 15·23	13	..	..	87	Poor.
Ditto .	Do. .	Timber seasoned in log for 12 to 24 months, ends treated with mud and cowdung, then converted into planks, scantlings and B. G. sleepers and seasoned for 6 to 18 months.	51	From 9·26 to 10·65	2	..	..	98	Do.
Ditto .	Do. .	Timber seasoned in log for 12 to 24 months, ends tarred, then converted into planks, scantlings and B. G. sleepers and seasoned for 6 to 18 months.	50	From 8·80 to 10·39	28	..	..	72	Do.
(24) *Pterocarpus Marsupium.*	Sambalpur Division, Bihar and Orissa.	Timber seasoned in log, bark on, for 12 to 24 months, then converted and seasoned in plank for 4 to 16 months.	27	24·23	100	..	..	..	A good deal of discolouration and some slight splitting.
Ditto .	Do. .	Timber seasoned in log, with bark off, for 12 to 24 months, then converted and seasoned in plank for 4 to 16 months.	26	29·25	73	27	..	..	Badly discoloured.
Ditto .	Do. .	Logs immersed in water for 4 months, seasoned on land for 14 months, then converted and seasoned in plank for 10 months.	54	13·32	82	18	..	..	A good deal discoloured.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(24) *Pterocarpus Marsupium*—contd.	Sambalpur Division, Bihar and Orissa.	Converted green into planks, allowed to season in the shade for 28 months.	47	13·73	91	9	..	..	Badly discoloured.
Ditto .	Do. .	Converted green into planks and immersed in water for 2 to 4 months, then allowed to season on land for 24 to 26 months.	57	13·88	98	2	..	..	Very good, and very little discolouration, especially those planks which were soaked for 4 months.
Ditto .	N. D. Kanara, Bombay.	Seasoned in log, with bark on, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	17	15·52	59	23	6*	23*	Badly discoloured.
Ditto .	Do. .	Logs rough squared and seasoned for 15 to 26 months, then converted and seasoned in planks for 10 to 21 months.	22	..	68	32	..	..	Do.
Ditto .	Do. .	Seasoned in log, with cut to centre, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	22	..	64	9	..	27	Do.
Ditto .	Do. .	Converted green, and planks seasoned for 36 months.	25	14·08	88	4	..	8	Do.
Ditto .	Do. .	Seasoned in log, with ends treated with Loracine, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	21	..	67	33	..	5*	Do.
Ditto .	Do. .	Sesasoned in log, with ends treated with cowdung and mud, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	23	..	48	22	4*	26	Do.

Ditto	Do.	Seasoned in log, with ends tarred, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	25	16·73	56	20	..	28*	Do.
Ditto	S. Chanda, Central Provinces.	Felled in January, seasoned in log, in shed, with bark on, for 22 months, then converted and seasoned in the plank for 13 months.	16	..	50	50	6*	12*	Fair, 66 per cent. of the planks slightly split.
Ditto	Do.	Felled in January, treated as above, but with bark off.	16	..	69	31	6*	..	Fair, 65 per cent. of the planks slightly cracked and several slightly warped.
Ditto	Do.	Felled in April, seasoned in log, in shed, with bark on, for 19 months, then converted and seasoned in plank for 13 months.	14	..	36	57	..	14*	Poor.
Ditto	Do.	Felled in April, treated as above, but with bark off.	12	..	8	84	..	24*	Do.
Ditto	Do.	Felled in August, seasoned in log, in shed, with bark on, for 15 months, then converted and seasoned in plank for 13 months.	13	..	23	38	..	61*	Do.
Ditto	Do.	Felled in August, treated as above, but with bark off.	13	15·81	15	46	..	39	Do.
Ditto	Do.	Logs immersed in water for 3 months, on land for 17 months, then converted and seasoned in plank for 14 months.	35	21·44	74	26	..	..	Fair to good, 70 per cent. of the planks were slightly cracked.
Ditto	Do.	Trees girdled and left standing for 22 months, then felled and converted and seasoned in plank for 13 months.	22	15·84	85	10	..	5	Fair to good, 50 per cent. of the planks were slightly cracked.
(25) *Schima Wallichii*	Kurseong Division, Bengal.	Logs seasoned with bark off, in open for 18 months, then converted and seasoned in plank for 15 months.	38	24·21	66	34	..	..	Poor, a good deal of fungus attacked.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(25) *Schima Wallichii* —contd.	Kurseong Division, Bengal.	Logs converted green and planks seasoned for 33 months.	46	22·24	78	22	..	..	Good.
Ditto	Do.	Logs immersed in water for 6 months, seasoned in log on land for 12 months, then converted and seasoned in plank for 15 months.	45	22·13	29	7	9*	..	Poor.
Ditto	Do.	Trees girdled for 12 months, then felled and converted and seasoned in plank for 21 months.	45	20·20	69	29	..	2	Good.
Ditto	Do.	Trees girdled for 18 months, then felled and converted and seasoned in plank for 15 months.	**84**	..	**93**	**8**	**1***	..	Very good.
Ditto	Do.	Trees girdled for 30 months, then felled and converted and seasoned in plank for 3 months.	47	..	85	15	..	..	Good.
Ditto	Do.	Seasoned in log, with ends tarred, for 12 to 30 months, then converted and seasoned for 3 to 21 months.	50	19·81	82	2	..	4	12 per cent. rotten and attacked by fungus all slightly cracked. Fair only.
Ditto	Do.	Seasoned in log, with ends treated, with Loracine, for 12 to 30 months, then converted and seasoned in plank for 3 to 21 months.	40	24·19	22	60	..	5	Poor, 13 per cent. rotten and attacked by fungus.
(26) *Shorea robusta*	Haldwani Division, United Provinces.	Seasoned in log, in shade, for 20 months, then converted and seasoned in plank for 12 months.	**36**	From 14·49 to **16·38**	**89**	**8**	**3**	..	Very good.

Ditto .	Do. .	Logs converted green, and planks seasoned in shade for 32 months.	30	From 13·95 to 14·83	87	13	..	..	Good.
Ditto .	Do. .	Logs immersed in water for 3 months, seasoned in log on land for 6 months, then converted and seasoned in plank for 23 months.	39	From 12·75 to 15·30	72	15	3	..	Do.
Ditto .	Singhbhum Division, Bihar and Orissa.	Seasoned in log, bark off, in shade for 16 to 20 months, then converted and seasoned in plank for 20 to 29 months.	22	From 11·18 to 14·11	..	27	..	100*	Poor, heavily attacked by borers.
Ditto .	Do. .	As above, but with bark on .	..	From 11·90 to 12·78	5	30	..	95*	Poor.
Ditto .	Do. .	Logs converted green and seasoned in shade for 45 months.	..	..	76	20	4*	4	Good, though 25 per cent. of the planks are slightly warped.
Ditto .	Do. .	Logs immersed in water for 4 months, seasoned in log on land for 14 months, then converted and seasoned under cover, in plank or rafter for 26 months.	45	From 11·91 to 12·30	73	27	..	..	Good.
Ditto .	Do. .	Converted green and planks immersed in water for 2 months, then seasoned on land, in shade for 43 months.	45	From 11·31 to 12·20	80	20	..	..	Good, though up to 25 per cent. slightly split.
Ditto .	Do. .	Seasoned in log, with ends treated with tar and cow-dung, for 16 to 24 months, then converted and seasoned in plank or rafter for 21 to 29 months.	15	From 11·16 to 14·25	..	40	..	100*	Poor.
Ditto .	Do. .	As above, but ends treated with Loracine.	25	From 14·28 to 15·56	64	36	..	4*	Fair, still partly green.

* NOTE.—Some or all of these planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	cracked.	Badly warped.	Insect attack.	
(27) *Stephegyne parvifolia.*	S. Chanda Division, Central Provinces.	Felled in January, seasoned in log, with bark off, in shed for 23 months, then converted and seasoned in plank for 12 months.	17	..	29	71	..	12*	Poor.
Ditto .	Do. .	Treated as above, but with bark on.	17	..	41	53	..	18*	Do.
Ditto .	Do. .	Felled in April, seasoned in log, with bark off, in shed, for 23 months, then converted and seasoned in plank, for 12 months.	11	..	18	64	..	36	Do.
Ditto .	Do. .	Treated as above, but with bark on.	12	..	17	75	..	33*	Do.
Ditto .	Do. .	Felled in August, seasoned in log, with bark off, in shed, for 23 months, then converted and seasoned in plank for 12 months.	10	16·68	10	40	..	80*	Do.
Ditto .	Do. .	Treated as above, but with bark on.	10	..	30	30	..	60*	Do.
Ditto .	Do. .	Logs immersed in water for 3 months, seasoned in log on land for 17 months, then converted and seasoned in plank for 15 months.	27	17·23	26	63	..	23*	Do.
Ditto .	Do. .	Trees girdled for 22 months, then felled and converted and planks seasoned for 13 months.	**17**	**18·45**	**64**	**24**	..	**12**	Fair to good.

28 *Tectona grandis* .	Do. .	Felled in January, seasoned in log, in shed, with bark on, for 21 months, then converted and seasoned in plank for 14 months.	19	..	84	16	..	..	Fair, 68 per cent. of the planks were slightly cracked.
Ditto .	Do. .	Treated as above, but with bark off.	11	..	27	73	..	..	Poor.
Ditto .	Do. .	Felled in April, seasoned in log, in shed, with bark on, for 18 months, then converted and seasoned in plank for 14 months.	15	..	33	67	..	..	Do.
Ditto .	Do. .	Treated as above, but with bark off.	20	..	35	65	..	..	Do.
Ditto .	Do. .	Felled in August, seasoned in log in shed, with bark on, for 15 months, then converted and seasoned in plank for 14 months.	14	15·87	57	43	..	..	Fair.
Ditto .	Do. .	Treated as above, but with bark off.	15	..	67	33	..	..	Good.
Ditto .	Do. .	Trees girdled for 22 months, then felled and converted and seasoned in plank for 12 months.	**19**	**30·25**	**84**	**16**	..	..	Do.
Ditto .	Do. .	Log immersed in water for 3 months, seasoned on land for 17 months, then converted and seasoned in plank for 15 months.	26	30·25	23	77	..	..	Poor.
(29) *Terminalia Arjuna*	Do .	Felled in January, seasoned in log, with bark off, in shed, for 23 months, then converted and seasoned in plank for 13 months.	**13**	..	**85**	**15**	..	..	Good.
Ditto .	Do. .	Treated as above, but with bark on.	13	..	77	23	..	8*	Do.

* NOTE.—Some or all of these planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	PERCENTAGE.				REMARKS.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(29). *Terminalia Arjuna* —contd.	S. Chanda Division, Central Provinces.	Felled in April, seasoned in log, with bark off, in shed, for 23 months, then converted and seasoned in plank for 13 months.	11	..	9	82	..	27*	Very poor.
Ditto .	Do. .	Treated as above, but with bark on.	15	..	27	53	9*	47*	Poor.
Ditto .	Do. .	Felled in August and seasoned in log, with bark off, in shed, for 23 months, then converted and seasoned in plank for 13 months.	15	14·11	60	40	..	..	Fair.
Ditto .	Do. .	Treated as above, but with bark on.	11	..	50	50	9*	..	Do.
Ditto .	Do. .	Log immersed in water for 3 months, then seasoned on land, in shed, for 18 months, then converted and seasoned in plank for 14 months.	27	16·43	44	52	4	..	Poor to fair.
Ditto .	Do. .	Trees girdled for 23 months, then converted and seasoned in plank 12 months.	**20**	**17·24**	**85**	**15**	..	..	Good.
Ditto .	Jhansi Division, United Provinces.	Logs left *in situ* as they were felled in the forest in open, for 18 months, then converted and seasoned in plank for 6 months.	10	From 7·56 to 8·75	..	40	20*	80*	Very poor, several planks also rotten.
Ditto .	Do. .	Logs seasoned in shade for 18 months, then converted and seasoned in plank for 6 months.	32	From 7·43 to 11·71	66	30	9*	Sap much attacked	Fair, though nearly all the sapwood is destroyed by borers.

Ditto .	Do. .	Logs immersed in water for 4 months, seasoned on land for 14 months, then converted and seasoned in balks for 6 months.	26	From 7·03 to 10·40	31	65*	39*	..	Poor, though sapwood not attacked by insects.
Ditto .	Do. .	Converted green, and seasoned in shed, in plank for 24 months.	**42**	**From 8·35 to 9·94**	**76**	**17**	**7**	Sap much attacked	Good, only sapwood damaged.
(30) *Terminalia belerica*	Kurseong Division, Bengal.	Seasoned in open, in log, with bark off for 18 months, converted and seasoned in plank for 15 months.	**21**	..	..	..	..	..	Both planks and rafters all rotten.
Ditto .	Do. .	Planks converted from green logs seasoned for 33 months, in the open.	17	..	..	..	..	..	Do.
Ditto .	Do. .	Seasoned in log, immersed in water for 5 months, on land for 15 months, then converted and seasoned in plank for 13 months.	27	..	..	..	..	..	Do.
Ditto .	Do. .	Trees girdled for 12 months, then felled and converted and seasoned in plank for 21 months.	33	..	73	3	..	27*	Good.
Ditto .	Do. .	Trees girdled for 21 months, then felled and converted and seasoned in plank for 12 months.	**31**	**36·90**	**90**	**10**	..	..	Do.
Ditto .	Do. .	Trees girdled for 30 months, then felled and converted and seasoned in plank and rafter for 3 months.	51	..	..	..	..	..	The planks all rotten, rafters fair, cannot stand girdled through two monsoons.
Ditto .	Do. .	Seasoned in log, with ends tarred, for 12 months, then converted and seasoned in plank for 21 months.	12	..	36	58	..	8	Poor.

* NOTE.—Some or all of those planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(30) *Terminalia belerica* —contd.	Kurseong Division, Bengal.	Seasoned in log, with ends tarred, for 18 to 24 months, then converted and seasoned in plank for 9 to 15 months.	40	..	15	38	..	20*	Poor, 34 per cent. attacked by fungus and rotten.
Ditto .	Do. .	Seasoned in log, with ends treated with Loracine, for 18 to 24 months, then converted and seasoned in plank for 9 to 15 months.	33	..	9	9	..	58*	Poor, 33 per cent. rotten.
(31) *Terminalia paniculata.*	N. D. Kanara, Bombay.	Logs seasoned with bark on, in open, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	29	14·97	38	62	..	..	Poor.
Ditto .	Do. .	Seasoned in log, with sides rough squared, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	28	..	47	46	..	7	Fair.
Ditto .	Do. .	Seasoned in log, with end cut to centre, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	24	..	54	46	..	..	Fair to good.
Ditto .	Do. .	Planks converted from green logs, and seasoned in open for 36 months.	**32**	**14·17**	**81**	**19**	..	..	Good.
Ditto .	Do. .	Seasoned in log, with ends treated with Loracine, for 15 to 26 months; then converted and seasoned in plank for 10 to 21 months.	26	..	38	62	..	..	Poor.

Ditto .	Do. .	Seasoned in log, with ends treated with cowdung and mud, for 15 to 26 months; then converted and seasoned in plank for 10 to 21 months.	24	..	38	62	..	..	Do.
Ditto .	Do. .	Seasoned in log, with ends tarred, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	23	17·85	61	39	..	..	Fair.
Ditto .	W. D. Kanara, Bombay.	Seasoned in log, in shade, for 21 months, then converted in October and seasoned in plank and scantling for 18 months.	23	..	43	22	..	48*	A certain amount of discolouration and fine cracking. Fair.
Ditto .	Do. .	Seasoned in log, in shade, for 27 months, then converted in April and seasoned in plank and scantling for 12 months.	8	..	62	38	..	..	Fair to good.
Ditto .	Do. .	Logs immersed in tidal creek for 12 months, then seasoned in log on land, for 9 months, converted in October and seasoned in plank and scantling for 18 months.	28	..	65	32	3	..	Fair to good.
Ditto .	Do. .	As above, but in log on land for 15 months, converted in April and seasoned in plank and scantling for 12 months.	36	..	73	27	..	..	Good.
(32) *Terminalia tomentosa.*	S. Chanda Division, Central Provinces.	Felled in January, seasoned in log, with bark off, for 21 months; then converted and seasoned in plank for 14 months.	15	..	40	60	..	..*	Fair.
Ditto .	Do. .	Treated as above, but with bark on.	19	..	6	89	..	42	Poor.
Ditto .	Do. .	Felled in April, seasoned in log, with bark on, for 18 months; then converted and seasoned in plank for 14 months.	28	..	11	89	..	4*	Do.

* NOTE.—Some or all of these planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage.				Remarks.
					Sound.	Badly cracked.	Badly warped.	Insect attack.	
(32) *Terminalia tomentosa*—contd.	S. Chanda Division, Central Provinces.	Treated as above, but with bark on.	15	..	..	93	..	66*	Very poor.
Ditto .	Do. .	Felled in August, seasoned in log, with bark off, for 15 months; then converted and seasoned in plank for 14 months.	13	..	23	77	..	23*	Poor.
Ditto .	Do. .	Treated as above, but with bark on.	12	23·51	..	100	8*	66*	Very poor.
Ditto .	Do. .	Trees girdled for 24 months, then felled and converted and seasoned in plank for 10 months.	28	From 14·66 to 17·95	76	17	..	7	Good.
Ditto .	Do. .	Trees girdled for 36 months, then felled and converted and seasoned in plank for 10 months.	7	..	14	70	..	86*	Left standing girdled too long, hence insect attack.
Ditto .	Do. .	Log immersed in water for 3 months, seasoned on land for 18 months; then converted and seasoned in plank for 14 months.	47	17·15	38	32	..	13*	Poor, much slight as well as bad splitting.
Ditto .	Do. .	Converted green, and seasoned in shed, for 11 months.	12	17·47	92	8	..	..	Very good.
Ditto .	Do. .	Converted green, planks immersed for 5 months in water and seasoned in shed for 6 months.	6	26·93	100	..	..	..	Still green, requires another six months to season.
Ditto	Do. .	Converted green, planks immersed for 9 months in water and seasoned in shed for 2 months.	7	..	100	..	..	..	Do.

Ditto .	Kheri Division, United Provinces.	Logs seasoned in shade for 18 months, then converted and seasoned in plank or rafter for 20 months.	41	From 15·60 to 19·67	56	44	..	..	Fair, a good number slightly warped and slightly split.
Ditto .	Do. .	Logs immersed in water for 4 months, seasoned on land for 14 months; then converted and seasoned in plank or rafter for 20 months.	42	From 11·12 to 18·43	76	19	..	5	Fair to good, nearly all slightly split and many slightly warped.
Ditto .	Do. .	Timber converted from green logs and seasoned in shade for 38 months.	**39**	From 13·15 to 13·73	**85**	**10***	**10***	**15**	Good, very slightly split.
(33) *Xylia xylocarpa*	N. D. Kanara, Bombay.	Seasoned in log, with bark on in open, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	25	17·08	8	88	8*	4	Poor.
Ditto .	Do. .	Logs rough squared and seasoned for 15 to 26 months then converted and seasoned in plank for 10 to 21 months.	24	..	..	100	..	..	Very poor.
Ditto .	Do. .	Seasoned in log. with cut to centre, for 15 to 26 months then converted and seasoned in plank for 10 to 21 months.	20	..	..	100	..	..	Do.
Ditto .	Do.	Converted green and planks seasoned for 36 months.	30	18·63	43	57	..	..	Fair to good.
Ditto .	Do. .	Seasoned in log, with ends, treated with Loracine, for 15 to 26 months; then converted and seasoned in plank for 10 to 21 months.	26	..	15	85	..	..	Poor.
Ditto .	Do. .	Seasoned in log, with ends, treated with cowdung and mud, for 15 to 26 months; then converted and seasoned in plank for 10 to 21 months.	32	..	16	84	..	..	Do.

* NOTE.—Some or all of these planks which are attacked by insects are also either badly cracked or badly warped or both.

APPENDIX IV—*contd.*

Species.	Locality.	Method of seasoning.	Pieces examined.	Moisture percentage at time of inspection.	Percentage. Sound.	Badly cracked.	Badly warped.	Insect attack.	Remarks.
(33)* *Xylia xylocarpa*—contd.	N. D. Kanara, Bombay.	Seasoned in log with ends tarred, for 15 to 26 months, then converted and seasoned in plank for 10 to 21 months.	27	16·77	11	89	..	..	Poor.
Ditto .	W. D. Kanara, Bombay.	Seasoned in log, in shade, for 21 months, then converted in October and seasoned in plank and scantling for 18 months.	13	..	7	54	7*	47*	Do.
Ditto .	Do. .	Seasoned in log, in shade, for 27 months, converted in April, and seasoned in plank and scantling for 12 months.	6	..	17	83	33*	50*	Very poor.
Ditto .	Do. .	Logs seasoned in tidal creek for 12 months, then seasoned in log on land for 9 months, converted in October and seasoned in plank and scantling for 18 months.	20	..	65	30	..	5	Good.
Ditto .	Do. .	Logs immersed in tidal creek for 12 months, then seasoned in log on land for 18 months, converted in April, and seasoned in plank and scantling for 12 months.	15	..	20	47	33*	27*	Poor.

* NOTE.—Some or all of these planks which are attacked by insects are also either badly cracked or badly warped or both.

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PREFACE

THIS note on Thitsi (*Melanorrhœa usitata,* Wall.) was written by Mr. Wright for the *Indian Forester.*

As it contains much useful information on the subject of tapping this species for Oleo-resin, it has been decided to issue it as an Indian Forest Record, supplementary to the one previously issued on the same subject by Messrs. Benskin and Rodger (Indian Forest Records, Vol. VI, Part III).

B. B. OSMASTON,
President, Forest Research Institute.

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A further note on Thitsi (*Melanorrhoea usitata*, Wall.) with special reference to the Oleo-resin obtained from it in the Lawksawk and Myelat States, Southern Shan States Forest Division

BY

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Provincial Forest Service, Burma.

1. Distribution.

IN the Lawksawk and Myelat States this tree occurs roughly between latitudes 20°60′ and 22°25′, and longitudes 96°25′ and 97°25′. It is found throughout the Lawksawk State except in the central southern parts, and is plentiful in the central northern portions of the State. In the Myelat it is found, except in negligible quantities, only in the Maw, Ywangan, Kyaukku and Hsa Möng Hkam States and occurs plentifully only in the extreme north-west corner of the Ywangan State and the extreme south-west portions of the Hsa Möng Hkam State. A rough estimate is given below of the areas in Reserves and Unclassed forests in which *Thitsi* is (A) plentiful (five or more *Thitsi* trees per acre) and (B) occurs but is not plentiful (under five *Thitsi* trees per acre).

(A) Areas in which THITSI *is plentiful.*

	Square miles.
(*a*) Lawksawk State—	
(1) Reserves	200
(2) Unclassed forests	300
(*b*) Myelat States—	
(1) Reserves	20
(2) Unclassed forests	80

(*B*) *Areas in which* THITSI *occurs but is not plentiful.*

	Square miles.
(*a*) Lawksawk State—	
(1) Reserves	300
(2) Unclassed forests	600
(*b*) Myelat States—	
(1) Reserves	50
(2) Unclassed forests	100

2. Habitat and Habit.

Thitsi is found in dry forests at elevations between about 300 and 3,800 feet. At the lower elevations it usually occurs in Indaing and semi-Indaing forests, and at the higher elevations is generally found in association with Oaks and Chestnuts. In the latter type of forests it is, as a rule, stunted and of poor development. In Indaing forests—forests in which *In* (Dipterocarpus tuberculatus) is the predominating species—it sometimes attains a girth of about 10 feet, but as a rule trees above 8 feet girth are uncommon. It attains its best growth and development in semi-Indaing forests—forests in which *Ingyin* (Pentacme suavis) and *Thitya* (Shorea obtusa) predominate and in which *In* (Dipterocarpus tuberculatus) is practically or entirely absent. In favourable localities, in these forests, it grows to a large size and trees above 12 feet in girth at breast-height are not uncommon. The largest sound tree measured by the writer, in his six seasons' touring over extensive areas of forest, had a girth of 12 feet 9 inches at 4 feet 6 inches from the ground, and a total height of 72 feet with a clear bole of 35 feet. Hollow and unsound trees of 13 feet 4 inches and 13 feet 7 inches girth have been measured.

In rich forests there may be as many as 15 to 20 *Thitsi* trees per acre, but as a rule the tree occurs in small numbers over large areas of forest in which it does not form more than about 3 per cent. of the growing stock.

The tree sheds its leaves in March and April, during which months it also flowers. It fruits from about the end of April to the end of June.

Owing to the two distinct kinds of the Oleo-resin obtained—the *black* and the *red*—the writer was of opinion that two varieties of the tree existed. A fairly large number of specimens were examined in various localities and no essential botanical differences could be discovered.

Enquiries have been made from Shans and Danus at a majority of the *Thitsi*-tapping villages in the Lawksawk and Myelat States and, in no instance, did the people recognize more than the one variety of the tree—the difference in colour of the Oleo-resin they consider is entirely dependent on the season of the year in which it is collected.

3. Natural regeneration.

In areas which are not subject to heavy tapping—and such areas are few and far between in accessible unclassed forests—*Thitsi* regeneration is, as a rule, good. In areas where heavy tapping is done annually, and has apparently been done year after year for several decades, the paucity of *Thitsi* seedlings, and indeed of saplings, and poles of the lower girth classes, is conspicuous.

In *Thitsi*-bearing forests, which, owing to their remoteness from villages, practically have not been exploited at all for some considerable time past, I have been struck by the excellence of the regeneration. General factors here being similar to those prevailing in other localities, with the exception of heavy tapping, has led me to the conclusion that the poorness of the regeneration in areas subject to annual heavy tapping may be attributed chiefly, if not entirely, to one cause, *viz.*, excessive and prolonged tapping. Heavily-tapped trees produce seed, but apparently their vitality is reduced to a point which renders them incapable of producing an adequate quantity of fertile seed. This matter requires further investigation and should not be accepted as proved. Experiments, which unfortunately the writer himself from various causes has not been able to undertake, require to be made to ascertain the relative percentage of germination of seed obtained from heavily tapped, lightly tapped and untapped trees, respectively.

Thitsi seedlings possess great power of resistance to destruction by fire. They are generally burnt down by annually recurring fires until a thick root-stock is formed, which produces a sufficiently strong shoot capable of resisting the action of fire.

4. Thitsi tapping apparatus.

The following articles are used in *Thitsi* tapping—

(1) An iron chisel (*sauk-kauk*) from 12 to 15 inches long, the lower 5 to 8 inches being hollow and roughly conical in shape. The remainder is solid, the upper 4 to 5 inches being wedge-shaped and bent so that the tip of the wedge is about half an inch off the straight. The cutting edge of the chisel is from $\frac{1}{2}$ to $\frac{5}{8}$ of an inch broad. The lower hollow portion forms the handle of the chisel into the bottom of which a bamboo or wooden plug is sometimes driven.

(2) A cylindrically shaped vessel (*Thitsi-laik pon*), about 9 inches high and about 6 inches in diameter, made of closely-woven bamboo strips (*hni-laung*) for holding the Oleo-resin. The upper portion of the vessel is narrowed down to form a neck about 4 inches in diameter, and is sometimes provided with a fairly close-fitting cover of tin or woven bamboo. The vessel is rendered absolutely proof against leakage by being given several successive coats of *Thitsi* (the Burmese name for the Oleo-resin).

(3) A small straining basket (*sit hkan*), about 3 inches both in height and width, made of thin strips of bamboo loosely woven, with meshes of about $\frac{1}{8}$ of an inch in diameter. This is placed in the neck of the *Thitsi-laik pon* so that its upper edge lies practically flush with the top of the former. It is held in this position by a bamboo pin about a quarter of an inch in diameter passing through it and the top of the neck of the *Thitsi-laik pon* from end to end.

(4) A *Zunkaw*—a flat piece of iron, about 5 inches long and $\frac{5}{8}$ of an inch wide, the edge of which is bent so as to form a scraper. This instrument is used to scrape the Oleo-resin out of the bamboo tubes. It is sometimes provided with a bamboo handle about 3 inches long and about an inch in diameter. Any *Thitsi* which adheres to the *Zunkaw* is scraped on to the bamboo pin over the *sit hkan* and gradually drops into the latter.

(5) *Hkayaung*—Bamboo tubes to receive the Oleo-resin from the tree. These are generally from 5 to 7 inches long and $1\frac{1}{4}$ to 2 inches in diameter with slanting mouth and sharpened edges to enable them easily to be driven into the bark at the apex of the triangular-shaped notches made. They are usually obtained from *Kyathaung* (Bambusa polymorpha), *Thanat* (Thyrsostachys Oliveri), *Wapyu* (Dendrocalamus membranaceus) or *Padoma* (Oxytenanthera albo-ciliata). The majority of tappers prefer *Kyathaung* (Bambusa polymorpha). *Tin* (Cephalostachyum pergracile) is never used owing to the dense tomentum which lines the inner walls of the culm.

(6) A *Hlega* or ladder, as a rule from 18 to 20 feet in length.

Two forms of portable ladders are used. In the Lawksawk State the ordinary type consisting of two parallel bamboo (usually *Myin*—Dendrocalamus strictus) supports held together by bamboo spokes 9 inches to a foot long, and spaced 15 to 18 inches apart, is commonly in use.

In the western parts of the Myelat States a most ingenious ladder is used. It consists of a single *Myin* (Dendrocalamus strictus) bamboo generally about 19 feet long and 2½ inches in diameter. Six treads are formed, the lowest being about 2′ 9″ from the ground and the highest about 2′ 6″ from the top end of the bamboo. The intermediate treads are thus 2′ 7″ apart. The treads are generally made from some hard wood—*Te* (Diospyros burmanica) is often used—they are about 2½ to 3 inches wide and are slightly concave on the upper surface to render them comfortable to stand on bare-footed. They project from 3 to 3½ inches on each side of the bamboo pole into which they are tenoned, and kept firmly in position by means of small bamboo or wooden wedges. The lower end of the bamboo is dove-tailed for a length of about 4 inches, the apex of the dove-tail ending immediately below a node, and fitted with iron shoes. This ensures the ladder not slipping along the ground when placed against the tree to be notched. To further ensure stablity, the upper end of the bamboo is fitted with a ⊔ shaped iron contrivance about 4½ inches wide and projecting for about 3 inches at right angles to the bamboo. This forms a kind of prong, the tips of which are finely pointed. It consists of iron about a quarter of an inch in diameter at its thickest point, and is rivetted to the bamboo, and further strengthened by a band of hoop-iron passing around the upper end of the bamboo. On arrival at the tree on which notching is to be done, the tapper jams the shoe-end of the ladder into the ground and then presses the pronged end against the tree with a jerk so that the prongs penetrate the bark, and the ladder is held firmly in position. The ladder is light and easily carried from tree to tree.

In cases where notching is done at a height which cannot be reached by portable ladders, the Shans construct a permanent ladder attached to the trees. It consists of a long bamboo placed vertically about 9 inches to a foot from the tree. Holes are cut through it at intervals of from 1 to 2 feet, and through each hole a flat bamboo stake which is pointed at one end is passed and driven into the bark of the tree. These stakes form the spokes of the ladder. Owing to the labour involved in their construction, these permanent, ladders are employed only in the case of really large and good *Thitsi*-producing trees. They are rarely seen.

(7) Last but not least, *Thitsi* tappers, more especially in the western parts of the Myelat, furnish themselves with a *Lethabo*—a kind of trumpet made from the upper ends of a buffalo or bullock-horn—which when blown produces a weird sound not much unlike a yodel. They blow this when moving about from tree to tree in the forests with the idea of frightening away bears—an animal greatly feared by them. During the past five years I have not heard of any *Thitsi* tappers having been mauled by bears while out tapping, but previous to this I understand tappers were occasionally mauled.

(8) The above paraphernalia (except the ladder, of course) are carried in a roughly woven bamboo basket (*Palaing*) about 15″×12″×8″, slung across the shoulder like a haversack by means of a finely-woven bamboo or cane band. The tapper has thus both his hands free to proceed with the business of notching, etc.

5. Method of tapping the trees.

The spot where a notch on the tree is to be made having been selected, loose bark scales and rubbish on the surface are removed by passing the sides of the chisel backwards and forwards over the part. Two cuts in the form of a V are then made upwards with the chisel. They are from 8 to 10 inches long and of a depth sufficient to cut through the bark to the wood. At their widest point the cuts are from 6 to 9 inches apart. The apex of the V points towards the ground—a line drawn vertically through the apex being practically parallel to the vertical axis of the tree. The chisel is then passed under the bark at the apex of the cuts, and pushed upwards in order to separate contact between the bark and the wood, without removing the former. A bamboo tube is then driven into the bark at the apex of the V-shaped cuts in such a way that the Oleo-resin which exudes from the cuts flows into the bamboo tube (See Frontispiece), the sharpened edges of the bamboo tube obviating the necessity of any special cut being made with the chisel to receive it before being driven into the bark. After a period of from 7 to 10 days any Oleo-resin contained in the bamboo tubes is collected by the tapper. It is scraped out of the tubes with the *zunkaw* and transferred to the *sithkan* or strainer whence it gradually drops into the *Thitsi-laik pon* in a more or less purified form.

If no Oleo-resin has exuded from a notch, as frequently happens, it is generally abandoned. A notch from which the Oleo-resin has exuded is further operated on as follows after the first collection has been made :—A cut is made with the chisel across the upper or wide end of the V-shaped cuts originally made, and a roughly triangular piece of bark with a base of from 6 to 9 inches and a height of from 6 to 8 inches is completely removed so as to expose the wood (see photograph). A thin shaving of bark is then pared off the edges of the two V-shaped cuts made in the first instance so as to reopen the resin-ducts. The bamboo tube is then driven into its old position, and the Oleo-resin which flows into it collected at the end of a further period of from 7 to 10 days after which, as a rule, the notch is abandoned. It should be noted that every time a tapper comes round to collect the Oleo-resin from the tubes one, two or more fresh notches are made on the tree, and specially so in the case of trees from which the Oleo-resin readily flows.

Where portable ladders are used—and this is the rule rather than the exception—tapping is very rarely done at a greater height than about 25 feet from the ground, and is confined almost exclusively to the bole of the tree. A favourite spot for a notch is on the bole immediately below the point where a fair-sized branch joins it.

The number of notches made on a tree depend generally on its size and *Thitsi*-producing capacity. The greatest number of notches of the year which I have counted on a tree is 32. This was in the western parts of the Ywangan State in the Myelat. The tree had a girth of 10′ 4″ at breast-height and a clear bole of 28′. I have been informed by experienced tappers, however, that as many as 50 notches are sometimes made in a year on a good *Thitsi*-producing tree with a girth of from 11 to 12 feet.

Throughout the Myelat and Lawksawk States where *Thitsi* occurs at all plentifully trees generally are excessively tapped, even poles down to 15 inches in girth at breast-height not being spared. In the Lawksawk State I have counted as many as six notches of the year on a pole of 16 inches girth. As the average area of wood exposed by a notch is, as a rule, about 25 square inches, and as it takes from about 5 to 7 years for a notch to completely heal over, the amount of injury sustained by a tree from excessive tapping can readily be appreciated. Large numbers of dead Thitsi trees are met, more especially in unclassed forests, and their death may be attributed to one cause and one cause only—excessive tapping.

Thitsi tapping is carried out from about the 15th of June to about the 15th of February and is at its height during July, August, September and October. No tapping is done from about the 15th of February to the 15th of June, as the flow of Oleo-resin from the tree either entirely ceases or exudes in such small quantities that tapping is not considered worth while. During the greater part of this period the tree is generally leafless or in flower or fruit. As a rule the *red* variety of *Thitsi* is produced during June, July, August and September and the *black* variety for the remaining period of the tapping season—from one and the same tree be it noted. As the monsoon rains are heaviest during June, July, August and September, the red colouration of the *Thitsi* obtained during these months would appear to be caused by the admixture of water which finds its way into the bamboo tubes containing the Oleo-resin.

6. The season's yield per tree and per chisel.

I have not myself been able to conduct any experiments in this matter ; but from information collected from a fairly large number of *Thitsi*-tappers, it would appear that the yield of *Thitsi* from trees of approximately the same girth and general appearance, growing in similar localities, varies considerably. Further, a tree of apparently good development and vigour often yields less *Thitsi* than a smaller poorly developed and less vigorous specimen. The size and appearance of a tree is apparently, therefore, not a guide as a rule as to its *Thitsi*-producing capacity. On the statements of tappers, the season's yield from the best *Thitsi*-producing tree does not exceed 5 viss (1 viss = 3·6 pounds), and an average yield of from 1½ to 2 viss from the best specimens operated on is considered good.

The *Thitsi*-tapping capacity of the individual Shan varies exceedingly. In localities where the tree is plentiful, a really hard-working and efficient tapper obtains from 100 to 120 viss of *Thitsi* in a season—but fortunately for the *Thitsi* tree energy is apparently not one of the characteristics of the Shan race, and the hard-working Shans I have met are few and far between—but the average tapper's collection can be taken at from 40 to 60 viss per season.

The price of the *red Thitsi* varies from Rs. 65 to Rs. 85, and of the *black* from Rs. 90 to Rs. 120 per 100 viss at the tapper's village, and the income derived from *Thitsi*-tapping forms an important subsidiary means of livelihood of a large percentage of the people residing in or near *Thitsi*-bearing forests.

7. Annual outturn and market value.

Statistics are not available of the quantity of *Thitsi* collected annually over the areas to which this article relates, but I give below the quantities

A heavily tapped *thitsi* tree in the unclassed forests near Konghang village, Lawksawk State.

Photo.-Mechl. Dept., Thomason College, Roorkee. Photo. by C. G. Rogers.

Observe the bamboo tubes (*Hkayaung*) to receive the oleo-resin from one of which a tape is suspended.

Observe also the triangular pieces of wood exposed by the notching.

Note the general gnarled appearance of the bark due to old healed notches.

of the Oleo-resin exported to Burma from the (whole) Southern Shan States on which duty was collected during the past five Forest years :—

1917-18	89,034 viss.	Duty Rs.	8,903
1916-17	68,800 ,,	,, ,,	6,880
1915-16	54,300 ,,	,, ,,	5,430
1914-15	57,400 ,,	,, ,,	5,740
1913-14	79,162 ,,	,, ,,	7,916

Under the Rules of the Burma Forest Act it is not necessary for any person to take out a license to collect *Thitsi* in unclassed forests in the Southern Shan States, and no duty is leviable on *Thitsi* whether collected for sale or for domestic or other purposes so long as it is not exported to Burma. On all *Thitsi* exported, or intended to be exported, to Burma by rail duty at the rate of Rs. 10 per 100 viss is collected before it is loaded on the train at the Forest Revenue Stations at Aungban, Kalaw and Myindaik on the Southern Shan States Railway. If exported by road or along the various caravan routes, duty at the same rate is supposed to be paid at the first revenue station it reaches in Burma. Of course, a good deal of leakage apparently occurs and appreciable quantities of *Thitsi* escape payment of duty.

A good deal of the Oleo-resin collected is utilized in the Southern Shan States, and large quantities of the product, which also are not subject to payment of duty, are exported to the Northern Shan States and Siam from States lying east of Taunggyi. Having regard to these facts it would be safe to assume that the total average annual outturn of *Thitsi* in the Southern Shan States is not less than about 1,40,000 viss.

The *black* variety of the Oleo-resin commands the best price, and fetches from Rs. 90 to Rs. 120 per 100 viss at the tappers' village, while the *red* variety sells at from Rs. 65 to Rs. 85 per 100 viss. It sometimes happens that the collectors themselves take the *Thitsi* for sale to brokers at Aungban or Kalaw on the Southern Shan States Railway or direct to Burma, when prices obtained are generally from about 10 to 20 per cent. higher than those above quoted. As a rule, however, tappers prefer to sell the *Thitsi* to purchasers who come round periodically to their villages.

8. Some uses of the Oleo-resin.

In the Southern Shan States, *Thitsi* is utilized in its liquid state as a natural varnish which is often applied to wood work, more especially in *hpoongyi Kyaungs* (monasteries) both in the internal and external parts of buildings. One or more thick coats of the Oleo-resin applied are said to add to the durability of the timber, and to render it immune against the attacks of white-ants. It is also largely used for caulking boats and wooden vessels intended for the storage of water. The Shans very often use vessels woven of fine strips of bamboo for the carriage and storage of water, and two or more thick coats of Thitsi applied to these both inside and outside render them perfectly watertight. If carefully used these vessels last for several years, especially if they are given a fresh coat of *Thitsi* once or twice a year.

Whenever any surface is to be gilded with gold-leaf, one or more coats of *Thitsi* invariably are applied to it before the gilding is undertaken.

Thitsi also is used largely in connection with the Lacquer industry which is carried on chiefly in the Kengtung and Laihka States and, in a smaller measure, in some of the other States in the Southern Shan States.

Probably the greater part of the *Thitsi* collected in the Southern Shan States, however, is exported to Burma, chiefly to Pagan and Mandalay—the important centres of the Burmese Lacquer industry.

9. Measures adopted in the past to regulate tapping.

Except in the case of the Panlaung Reserve—a Reserve of 112 square miles situated in the Ywangan State of the Myelat—in which the right to tap *Thitsi* for sale was granted at the time of settlement to 3 villages comprising 75 households, no licenses nor permits to tap *Thitsi* in Reserves have been issued in the Southern Shan States Division, at any rate during the past six years. The permits which have perforce had to be issued in the case of *bonâ fide* right-holders have laid down, among other things, the areas in which the tapping was to be done, the minimum size of the trees to be tapped, and the maximum number of notches to be made per year on a tree.

The main reason for not issuing licenses or permits to others than *bonâ fide* right-holders to tap *Thitsi* in Reserves is attributed to the fact that previous to reservation all *Thitsi*-bearing areas contained in existing Reserves had been subject to heavy, and more often than not, excessive tapping, and the trees require rest to recover. It is significant that the matter of excessive tapping should have attracted the attention of the Forest Settlement Officer—an Assistant Superintendent of wide experience in the Southern Shan States, and more especially in the parts to which this article relates—during the settlement of the Zawgyi Reserve—a Reserve of some 730 square miles contained chiefly in the Lawksawk State, and Maw State of the Myelat.

In his settlement report he says : "I have allowed no *Thitsi* in the Lawksawk Circles as my observations went to show that the trees had already been over-tapped, and that further extraction should be under proper control."

In so far as unclassed forests are concerned, no measures to regulate *Thitsi* tapping have been, or could be, taken by the Forest Department in the past, and unless radical changes take place this state of things must continue. Under the Rules of the Burma Forest Act, as they stand at present, *Thitsi* being an unreserved tree it may be tapped or cut for any purpose whatever without a license. In fact, every *Thitsi* tree in the Southern Shan States unclassed forests—all forests not included in Reserves—could be completely exterminated and the Forest Department apparently would be powerless to interfere. The result is that *Thitsi* tapping in the past has continued in unclassed forests without let or hindrance.

10. Suggestions for the regulation and control of Thitsi tapping in the future.

In Reserved forests the regulation and control of Thitsi tapping will present no difficulties. No tapping can be done in a Reserve without a license or special permit issued by the Divisional Forest Officer, who may introduce in the license such conditions with regard to the tapping as he may consider necessary or desirable. In view of the fact, however, that all Reserves in the Lawksawk and Myelat States are of comparatively recent origin and that practically all *Thitsi*-bearing forests contained in them had been heavily, if not excessively, tapped previous to reservation, it is important that no *Thitsi* tapping be permitted in them—except, of course, in the case of *bonâ fide* right-holders, the exercise of whose rights it is not possible to withhold—for a period of at least another five years in order that the trees may be given a chance of recovering from the heavy tapping to which they, as a rule, had been subjected before the Reserves were formed.

As regards unclassed forests, the matter stands on an entirely different footing, and there is no denying the fact that the introduction of any measures to regulate and control *Thitsi* tapping is beset with many difficulties.

As I have stated previously, the Forest Department has no power under the Rules of the Burma Forest Act, as they exist at present, to interfere in any way with tapping in unclassed forests. But, assuming —an improbable assumption—that the Rules were modified and the Forest Department vested with the necessary powers, it would still be a difficult, if not impossible, matter to regulate and control *Thitsi* tapping without the active co-operation and help of the Chiefs of States—co-operation and help which would probably not be forthcoming unless the Chiefs themselves benefited directly—and without a large increase in the cadre of the Forest staff—an increase which would not be justifiable, especially from a financial point of view. Difficulties are further enhanced by the unwieldy size of the Division, which covers an area of about 36,000 square miles—though a large percentage of this area is destitute of forest growth, still the ground has to be covered to arrive at forest-clad areas—and the scattered nature of the *Thitsi*-bearing unclassed forests.

What is required then is to enlist the co-operation of the Chiefs and of the machinery employed by them in the ordinary administration of their States to bring into force any approved measures which might be introduced for the regulation and control of *Thitsi* tapping in unclassed forests.

Now, hitherto the duty collected on all *Thitsi* exported to Burma—and practically all such *Thitsi* was obtained from tapping in unclassed forests—has been wholly credited to the revenues of the Forest Department, and so long as this continues it is unreasonable to expect the Chiefs to assist the Forest Department in anything appertaining to *Thitsi* tapping. What is indicated then is to give the Chiefs of States a fair percentage, say, 50 per cent. of the duty collected on *Thitsi* obtained from unclassed forests, in return for assistance to be rendered by them in the enforcement of measures formulated to regulate and control the tapping. True, the duty hitherto collected has been small, but is capable of considerable expansion without conflicting with any measures which might be adopted to regulate tapping. Why should duty only be collected on *Thitsi* exported to Burma? I would make duty payable on all *Thitsi* not collected especially for the *boná fide* domestic use of the people in the Southern Shan States, whether it is exported or not to Burma or elsewhere. In short, I should make duty payable on all *Thitsi* collected for trade purposes, but would fix the duty on the product used for trade purposes within the limits of the Southern Shan States at half the rates fixed for it on export.

Last year proposals were formulated by the Chief Conservator of Forests, Burma, and the Superintendent and Political Officer, Southern Shan States which, among other things, provide that the management of the unclassed forests in all matters other than those relating to Teak, should be vested in the Chiefs of States, who are to be assisted by an adviser in Forest matters. The Myelat States are not included in this scheme. If these proposals are sanctioned by Government, they should simplify the introduction of measures to regulate and control *Thitsi* tapping in the unclassed forests.

The steps which, it is suggested, should be taken to regulate *Thitsi* tapping in unclassed forests are :—

(*i*) To divide the *Thitsi*-bearing unclassed forests into a number of tapping circles, each of which should be divided into blocks to correspond with the tapping-rotation adopted—which should not be less than seven years—and to permit tapping only in the block open for the year. The blocks will, of course, be open to tapping in rotation. The tapping circles should, as far as possible, be so arranged as to cause the minimum inconvenience to people of villages which practise tapping.

(*ii*) To limit the minimum size of the trees to be tapped. Experiments will have to be made in this respect to ascertain the girth at which trees can be tapped without seriously affecting their growth and productivity. As it will take time to collect useful and reliable data, the minimum tapping girth limit might be fixed tentatively at 4 feet.

(*iii*) To fix the maximum number of notches which may be made on trees of different girth.

This is another matter which will have to be decided on the results of experiments which should be undertaken. As a tentative measure, six notches annually may be fixed for trees between 4 and 5 feet girth, and the number increased relatively for trees in the higher girth-classes.

(*iv*) To supplant the present pernicious method, by which pieces of bark are entirely removed from the tree during the process of notching, by some more rational method of tapping somewhat similar to that followed in the case of rubber.

Action is also called for to prohibit or, at any rate, reduce the very large number of *Thitsi* trees which are annually destroyed in *taungyas*—areas cleared for purposes of shifting cultivation.

The measures which, it is suggested above, should be taken to regulate *Thitsi* tapping will have to be introduced gradually, and with tact. They cannot be introduced together, nor is it intended that they should. The Shans are a most conservative people, and there is no doubt that they will resent the introduction of even the most lenient measures which might interfere with their long established freedom of action. It will be very difficult to make the people understand that it is in their own interests that the measures are being introduced, for they are apparently unable to realize that they cannot eat their cake and have it. *Thitsi* tapping in the Southern Shan States often forms an important subsidiary means of livelihood of a large percentage of the population of villages neighbouring on *Thitsi*-bearing forests; and if a sustained annual yield is to be maintained in the near future, some of the measures at least which have been suggested above will have to be introduced. The people will no doubt oppose these measures, but their opposition should not be allowed unduly to act as a heavy drag-chain on the wheels of regulated progress.

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HOPEA CANARENSIS, *Hole*

BY

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Introduction.

IN 1913, Mr. F. A. Lodge, C.I.E., Conservator of Forests, sent fruiting specimens of a *Hopea* to Dehra Dun for identification which could not be matched there with descriptions or specimens. Specimens were accordingly sent to Kew but they could not be matched there. Mr. C. D. McCarthy, Conservator of Forests, subsequently sent to Dehra Dun flowering specimens of the same tree in 1917, thus enabling a full description to be drawn up which is given below :—

Description.

HOPEA CANARENSIS, *Hole.*

(*Indian Forester*, XLIV, p. 575, December, 1918.)

Species allied to *H. racophloea,* Dyer, and *H. glabra,* W. & A. From the former it differs in the more numerous lateral nerves, the rounded or cordate base of the leaves, the eciliate calyx lobes with the outer two larger and different in shape and the ovoid or oblong stylopodium ; from the latter it differs in the larger leaves, glandular nerve axils, longer petioles and broader fruit wings.

Vernacular name *Malai haiga.*

Large tree producing clean boles 6 to 8 ft. in girth and 50 to 60 ft. long.

Young shoots glabrous, bark on twigs pale brown.

Stipules not seen but apparently small, not amplexicaul.

Petiole length 0·5 *in.* to 1·1 *in.*, stout, glabrous, rugose.

Leaves alternate, simple, penninerved.

Length 4 *in.* to 7 *in.*, width 1·7 *in.* to 3·5 *in.* ovate to oblong, base rounded or cordate. Apex obtuse or acuminate.

Coriaceous, glabrous above and below. Secondary nerves 6-10 on each side of midrib, arcuate, prolonged parallel to margin. Midrib and secondary nerves slightly prominent above, strongly prominent below, tertiary nerves parallel, perpendicular to midrib, the tertiary nerves and reticulate nervules sometimes more prominent above than below; in the majority of the secondary nerve axils are large glabrous gland-like swellings which are perforate below, leaf-surface above minutely pustulate. Margin cartilaginous, slightly undulate.

Inflorescence. Flowers in fascicled axillary panicles, the panicles glabrous, 2 to 4 together, attaining a length of 2 *in.* to 6 *in.*

Bracteoles at base of pedicel apparently early deciduous while flower still in bud, only one seen, oblong, 0·06 *in.* long, 0·03 *in.* wide, glabrous dorsally, on inner surface a few minute hairs.

Pedicels stout, 0·04 *in.* to 0·08 *in.* long, jointed at base, glabrous.

Calyx tube glabrous, 0·02 *in.* to 0·04 *in.* long, adnate to torus.

Calyx lobes 5, imbricate, glabrous. The two exterior the largest, ovate-oblong to deltoid, obtuse, length 0·16 *in.* to 0·18 *in.*, width 0·09 *in.* to 0·1 *in.*, eciliate, the three interior lobes sub-orbicular, acute, length 0·1 *in.* to 0·13 *in.* and width 0·09 *in.* to 0·12 *in.*, eciliate or with a few minute hairs on the margin above.

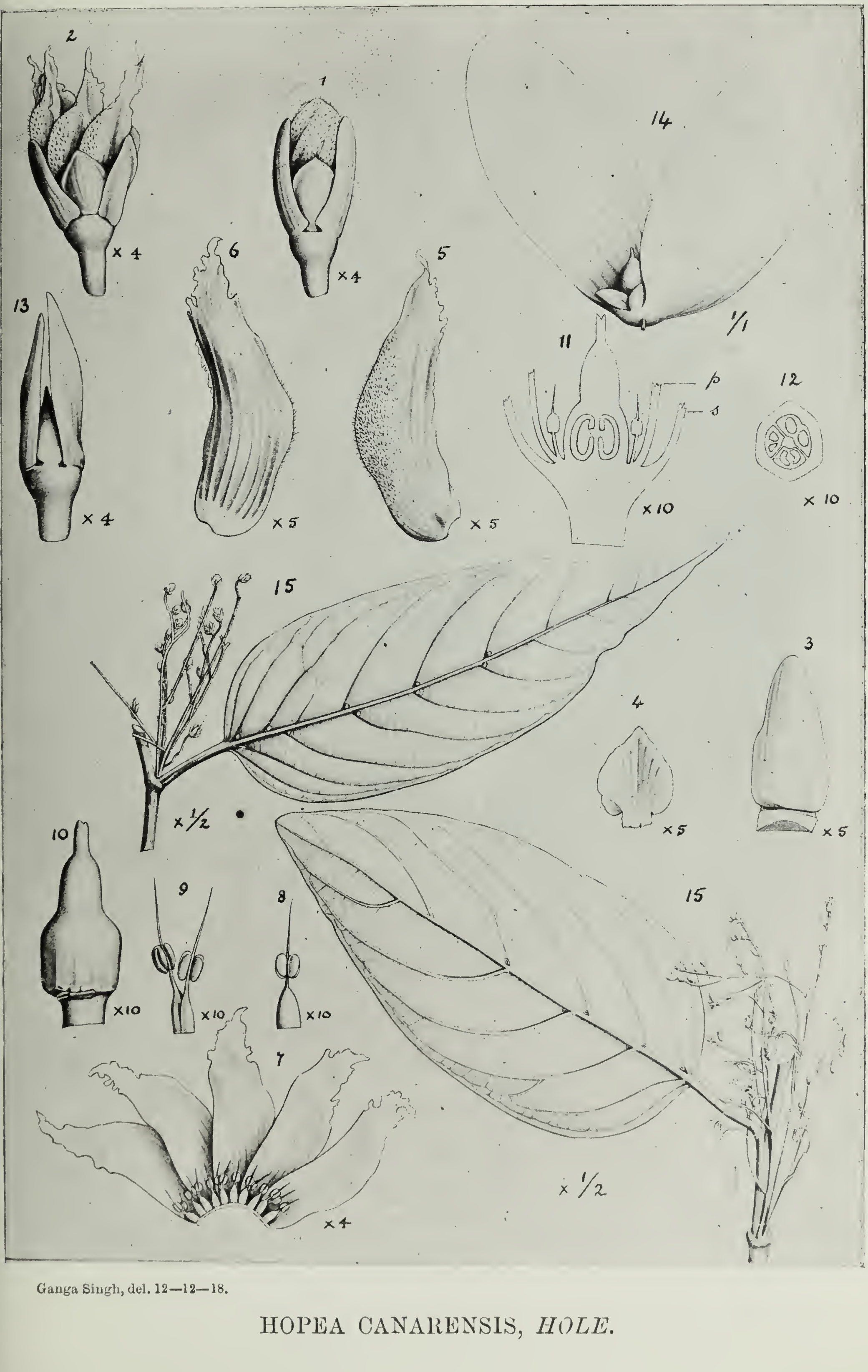
Petals 5, contorted, overlapping sometimes to the left and sometimes to the right, slightly connate at base, length 0·33 *in.* to 0·36 *in.*, width 0·1 *in.*, falcate-oblong, terminating in an ovate or slightly flabelliform, membranous, crisped apex, glabrous within, 10 to 12 nerved. According as the overlap is to the right or left, the right or left-hand half is dorsally densely stellate pubescent.

Stamens 15, adnate to base of corolla, filaments much dilated and flattened at base, the filament of each alternate stamen is more or less adnate to the filament of the stamen immediately in front of it, there thus being 5 single stamens and 5 pairs of stamens; anthers introrse, 2-celled, longitudinally dehiscent, suborbicular, diameter exceeding 0·01 *in.* but less than 0·02 *in.*, connective produced as a slender awn, 0·04 *in.* long.

Ovary superior, glabrous or very minutely or sparsely puberulous above, 0·03 *in.* to 0·04 *in.* long, stylopodium stout, ovoid or oblong, length 0·03 *in.* to 0·04 *in.*, glabrous or very minutely and sparsely puberulous, style short, cylindrical 0·02 *in.* long, glabrous, minutely 3-lobed at apex.

EXPLANATION OF PLATE.

Fig. 1. Flower bud × 4.
Fig. 2. Flower × 4.
Fig. 3. Large exterior calyx lobe × 5.
Fig. 4. Small interior calyx lobe × 5.
Fig. 5. Petal from back × 5.
Fig. 6. Petal from front × 5.
Fig. 7. Corolla from inside with stamens at base × 4.
Fig. 8. Single stamen × 10.
Fig. 9. Two stamens with their filaments adnate at base, forming a pair × 10.
Fig. 10. Ovary × 10.
Fig. 11. Longitudinal section of ovary showing insertions of calyx lobes, corolla and stamens, *s* calyx lobe, *p* petal × 10.
Fig. 12. Cross section of ovary × 10.
Fig. 13. Young fruit × 4.
Fig. 14. Mature fruit × 1/1.
Fig. 15. Flowering twigs × ½.



Ganga Singh, del. 12—12—18.

HOPEA CANARENSIS, *HOLE*.

Ovary 3-celled, ovules 2 in each cell, ovules more or less completely anatropous, raphe ventral, micropyle superior.

Fruit ovoid, 0·5 *in.* to 0·6 *in.* long, enclosed in the persistent calyx lobes, two of these lobes much enlarged, forming erect oblong or broadly elliptic wings 2 *in.* to 3 *in.* long and 0·7 *in.* to 1·0 *in.* wide, with 9-12 longitudinal nerves joined by cross veins, both nerves and veins being usually prominent.

A third calyx lobe, also, is sometimes slightly enlarged and attains a length of 0·6 *in.*

Distribution.

So far as is known at present, this species is confined to the Western Ghats hill-forests along the South Canara-Mysore boundary.

Herbarium Specimens.

Dehra Dun herbarium Nos. 6309, 6310, 10251-10253, 18214, 18216-18222.

Notes.

Our knowledge regarding the distribution, uses and vernacular names of the three species, *Hopea glabra, H. racophlœa* and *H. canarensis,* is at present very imperfect. In the *Flora of Madras* (Calcutta, 1915, p. 82), Gamble has recently united *Hopea glabra,* W. & A. with *Hopea Wightiana,* Wall. The latter, however, appears to differ strongly from the former in having persistently pubescent longer petioles, larger leaves often cordate at base, more persistent bracteoles, outer calyx lobes shorter in flower, and inner calyx lobes usually more ciliate. The distribution of the two trees also appears to be different. *Hopea Wightiana* is common in the moist forest at the foot of the Ghats in the S. Konkan and N. Canara (Bombay) and S. Canara (Madras), and Mr. H. Tireman has recently sent specimens of it to Dehra Dun from the Western Ghat forests of Coorg. In S. Canara large tracts in the plains are stocked with it, but further south it apparently becomes rare. In Travancore, according to Bourdillon, it was "at one time, no doubt, very common in the plain-forests of Travancore, but now almost exterminated, as it does not ascend the hills. It may be seen in groves and along road-sides in the low country." (*Trees of Travancore,* 1908, p. 38.) *Hopea glabra,* on the other hand, appears to be most abundant in the Tinnevelly district. In Travancore it occurs locally along rivers at 200 ft. elevation but is not common (*fide* Bourdillon, l. c.). The material now available of these two species is somewhat scanty, and until we know them better it seems at present preferable to keep *H. glabra* distinct from *H. Wightiana*, the former at present being known to occur only in Tinnevelly and Travancore. *Hopea racophlœa*, so far as our information goes at present, occurs only in the Anamally and Wynaad (Carcoor Ghat) forest at 2,000 to 3,000 ft. and in the evergreen hill forests of Travancore from 500 to 2,500 ft., where Bourdillon says it is rare.

Finally, *Hopea canarensis* is at present only known from the hill forests of S. Canara. It is reported not to extend into the plains. As regards the value of the wood of these species, Beddome reports that *Hopea Wightiana* is a "first rate coppice firewood," while *Hopea glabra* is "par excellence the timber of Tinnevelly" (*Fl. Syl.* t. 96). Talbot (*Forest Flora* I. p. 113) says the wood of *Hopea Wightiana* is much used for building purposes in North Canara and is exported from that district in considerable quantities to Calicut. *Hopea racophlœa* is said by Beddome to be a "very large tree with a most valuable hard timber" (Ic. t. 185), while Gamble (*Man.* 1902, p. 74) says it has a "hard, heavy, durable timber likely to be useful for engineering purposes." The timber of *Hopea canarensis* is at present practically unknown, but there is little doubt that it will prove to be not less valuable than that of its nearest allies *H. glabra* and *H. racophlœa*.

As regards the vernacular name which has been reported from S. Canara for *Hopea canarensis*, it is interesting to note that Mr. A. W. Lushington (*Vern. List of Trees, Shrubs and Climbers of Madras*, Vol. II-B, 1915, p. 68) gives *malehaiga* or *malehegge* as the Canarese name for *Hopea glabra*, while (l. c. Vol. II-A, p. 55) no Canarese name is given for *Hopea racophlœa*. Further inquiry is necessary to show how far these species can be distinguished by their vernacular names and also to determine the limits of their distribution.

Acknowledgments.

The writer desires to tender his warm thanks to Mr. Lodge and Mr. McCarthy for the specimens and information regarding this tree which they have sent to Dehra Dun, and to Sir David Prain for kindly having our specimens compared with the material at Kew.

INDIAN FOREST RECORDS.

Vol. VII 1919 Part IV

IXORA BUTTERWICKII, *Hole*

BY

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Introduction.

IN September 1917, Mr. A. J. S. Butterwick, Extra-Assistant Conservator of Forests, sent specimens of an *Ixora* to Dehra Dun for identification which could not be matched there and which appeared to belong to a new species. Specimens of it were accordingly sent to Kew for comparison with the material there. In his reply Sir David Prain wrote that the specimens belonged to " an entirely new species of *Ixora* which may safely be described."

Description.

Ixora Butterwickii, *Hole* (*Indian Forester* XLV, p. 15, January 1919). Species allied to *I. spectabilis*, Wall, and *I. pendula*, Jack; from the former it differs in the larger size and shape of the leaves, more numerous lateral nerves and wider panicle ; from the latter it differs in the shorter corolla tube, longer anthers and wider panicle.

Large evergreen shrub attaining a height of 11 feet and basal girth of 9 inches.

Young shoots glabrous (except the branchlets of the panicle), elliptic or quadrangular.

Stipules interpetiolar, broadly ovate, 0·1 *in.*—0·25 *in.* long (excluding the subulate apex), dorsally keeled above, the keel being produced as a subulate cusp equal in length to the stipule. The margins of the stipules at the base are more or less produced intrapetiolarly and are sometimes connate, thus forming a complete sheath around the stem.

Leaves opposite, simple, penninerved. The lower leaves are elliptic, shortly and bluntly acuminate with a rounded base, or oblanceolate with a more elongate acumen and cuneate base. Petiole stout 0·3 *in.*—0·5 *in.* long, glabrous. Length of the leaves 9 *in.*—13 *in.*, and width 4 *in.*—6 *in.* Membranous or thinly coriaceous, glabrous above and below. Secondary nerves 16-20 on each side of midrib, ascending, curved above. Midrib and secondary nerves prominent above, the midrib somewhat sulcate, both very prominent below. The reticulate nervules about equally prominent above and below. Leaves green when dry, the lower surface slightly paler than the upper. Leaf-surface shining above, minutely papillose below. Margin entire, thinly cartilaginous, slightly undulate. Uppermost pair of leaves, *i.e.*, the first pair below the panicle, sessile, well-developed, and provided with a well-developed pair of inter-petiolar sheathing stipules. The leaves elliptic to elliptic-ovate, obtuse, base cordate. Length 2·0 *in.*—7·25 *in.*, width 1·25 *in.*—4·25 *in.* Secondary nerves 12-16 on each side of the midrib. Otherwise like the lower leaves.

Inflorescence. Flowers in cymes arranged in a pedunculate, lax, corymbiform, terminal panicle, peduncle 3·75 *in.*—6·25 *in.* long, more or less compressed, glabrous, 0·1 *in.*—0·15 *in.* wide, length of panicle (excluding the peduncle) 3·25 *in.*—6·0 *in.* and width 5 *in.*—10 *in.*, young branches puberulous. Basal branches at right angles to the rhachis.

Bracts subtending the pedicels, and panicle branches linear lanceolate, 0·06 *in.*—0·23 *in.* long, increasing in size downwards, those subtending the basal branches of the panicle being rarely foliaceous, sessile, broadly ovate-elliptic with a mucronate apex and lamina decurrent at the base, attaining a length of 1·2 *in.* and width 0·75 *in.* Stipules small, adnate to base of bract and not sheathing.

Bracteoles usually 2, opposite, at the apex of each pedicel, linear lanceolate, 0·03 *in.*—0·06 *in.* long. Bracts and bracteoles persistent.

Flowers sessile or shortly pedicellate.

Pedicels 0·02 *in.*—0·07 *in.* long, puberulous.

Calyx-tube broadly obovoid or slightly urceolate, somewhat compressed, 0·05 *in.*—0·07 *in.* long, puberulous.

Calyx-lobes 4, broad ovate, obtuse and usually more or less irregularly denticulate, 0·03 *in.*—0·04 *in.* long, eciliate, glabrous.

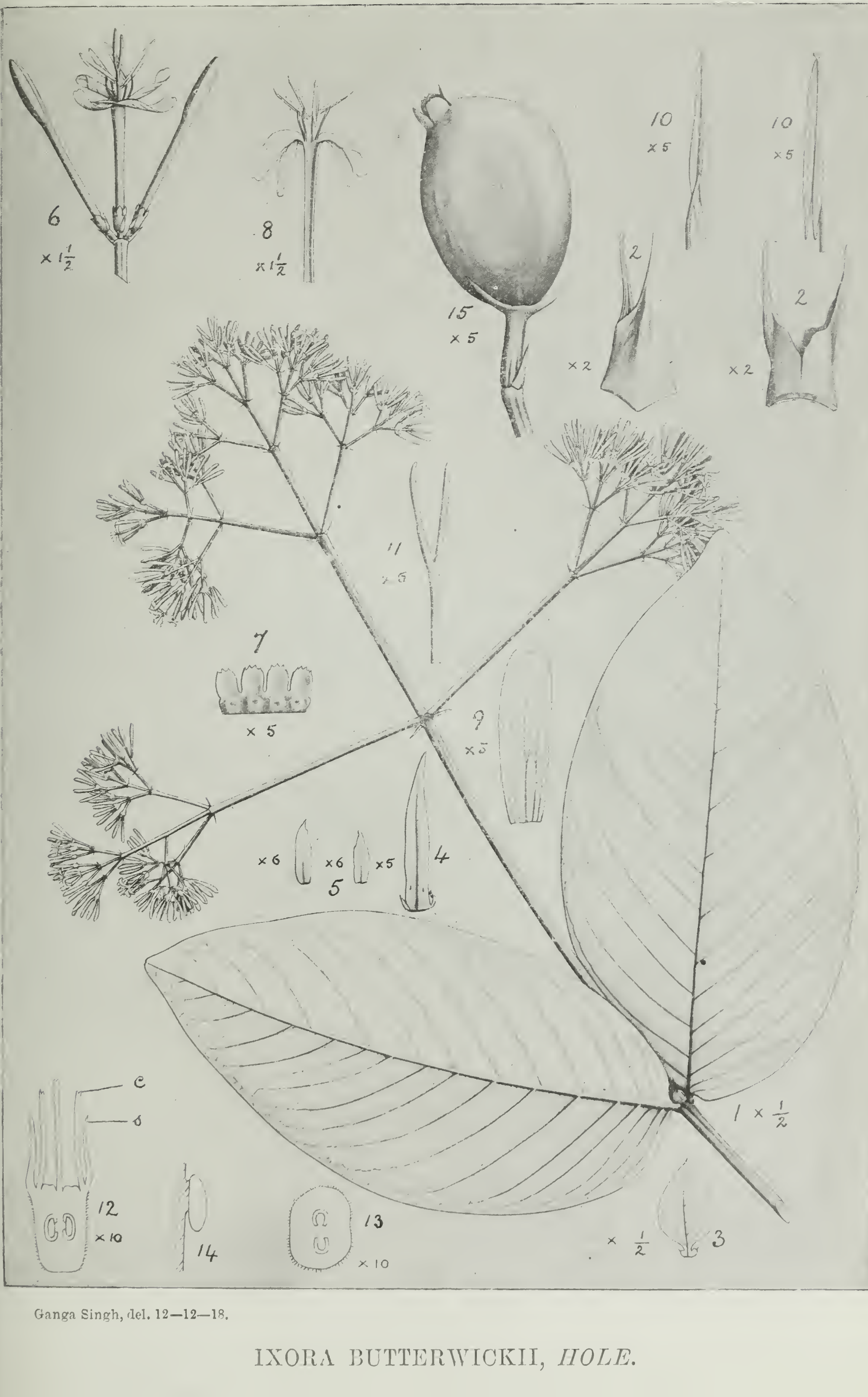
Corolla hypocrateriform, crimson in the fresh flowers.

Corolla-tube slender, cylindrical, slightly expanded above, 0·45 *in.*—0·5 *in.* long, glabrous within and without.

Corolla-lobes 4, contorted in bud and overlapping to the left, oblong, obtuse or emarginate, 0·24 *in.*—0·26 *in.* long, 0·07 *in.*—0·08 *in.* wide, in open flower reflexed or spreading and twisted, glabrous.

EXPLANATION OF PLATE.

Fig. 1. Panicle and uppermost pair of leaves × ½.
Fig. 2. Sheath formed of two connate interpetiolar stipules × 2.
Fig. 3. Foliaceous bract subtending a basal branch of the panicle × ½.
Fig. 4. Usual form of bract subtending the basal branches of the panicle × [illegible].
Fig. 5. Bracteoles from apex of pedicels × 6.
Fig. 6. Cyme of 3 flowers × 1½.
Fig. 7. Calyx lobes × 5.
Fig. 8. Upper part of corolla tube cut open × 1½.
Fig. 9. Corolla lobe × 5.
Fig. 10. Stamens × 5.
Fig. 11. Stigmas × 5.
Fig. 12. Longitudinal section of ovary × 10; *s* calyx lobe, *c* corolla.
Fig. 13. Cross section of ovary.
Fig. 14. Ovule showing broad lateral attachment.
Fig. 15. Immature fruit × 5.



Ganga Singh, del. 12—12—18.

IXORA BUTTERWICKII, *HOLE*.

Stamens 4, inserted on the mouth of the corolla tube, alternating with the corolla-lobes, erect and exserted. Filaments 0·08 *in.*—0·1 *in.* long, glabrous, anthers linear, 0·22 *in.*—0·23 *in.* long, dorsifixed near the base, 2-celled and dehiscing longitudinally, more or less sagittate at base, the connective terminating above in a stout incurved point.

Ovary inferior, 2-celled, one ovule in each cell, peltately attached to the septum, micropyle downwards.

Style slender, glabrous, exserted, 0·12 *in.*—0·15 *in.*

Stigmas 2, slender, 0·12 *in.* to 0·16 *in.* long.

An epigynous disc covering the ovary from the insertion of the corolla to the base of the style.

Fruit. Only immature fruit seen, subglobose, 0·23 *in.* in diameter, crowned obliquely by the persistent calyx lobes. Appears to be usually one-seeded.

Distribution.

This species is only known at present from Inbinyedwet in the Palwe Reserve of the Pyinmana Forest Division, in the Yamethin district of Burma.

Herbarium specimens.

Dehra Dun herbarium Nos. 19781-19786, 19976-19979.

Notes.

The determination of the affinities of this species and the selection of the diagnostic characters separating it from its nearest allies has been a matter of some difficulty. Many of the Indian species of *Ixora* are very variable and exhibit very remarkable differences; for example, in the shape and size of the upper and lower leaves. In the absence of plentiful material, therefore, the range of variability of a species cannot be determined with any accuracy, and such material is not yet available in the case of several species. The common forms of *Ixora spectabilis*, Wall. differ strongly from the present species in several characters, in addition to those which have been selected above as being of special diagnostic value. In such forms, the leaves turn brown on drying and are hoary beneath, the pedicels are shorter and the calyx lobes are more hairy and more acute. At the same time somewhat doubtful specimens are found (*e.g.* Lace No. 167, Amherst, in herbarium Dehra Dun) which do not show these characters. Such forms require further study, but the writer is inclined to assign them provisionally to *Ixora spectabilis*, Wall. Kurz also notes that *Ixora spectabilis*, Wall. is a small tree and that its flowers are white. Additional characters separating *Ixora pendula*, Jack, from the present species are found in the base of the leaves of the former being always more or less cuneate, the corolla tube being frequently puberulous without, the calyx tube being often glabrous, and in the more slender peduncle which is, as a rule, clearly pendulous.

Acknowledgments.

The writer has much pleasure in naming this species after Mr. A. J. S. Butterwick who has steadily endeavoured to apply in the forests of Burma the botany he learnt during his training at Dehra Dun, and to whom we are indebted not only for the specimens of this species but for much valuable material which he has sent to us from time to time.

The writer also desires to tender his warm thanks to Sir David Prain for kindly having our specimens compared with the material at Kew, also to Colonel Gage and Mr. C. C. Calder for very kindly sending to Dehra Dun the Calcutta material of *Ixora spectabilis*, Wall. and *Ixora pendula*, Jack, for examination.

INDIAN FOREST RECORDS

Vol. VII.] 1919 [Part V.

Notes on the Larvae and Life Histories of Prionine Beetles. Coleoptera, Cerambycidae, Prionini.

By

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INTRODUCTION

TWO factors have influenced the preparation of this record, which is the first of a series containing similar subject matter.

1. In the course of sanctioned investigations in the ethology and economic status of the insect fauna of certain Indian timber trees information is constantly accumulated that is not directly on the main lines of research. Beyond recording the data and material incidentally encountered, it is generally undesirable and frequently impossible to pursue the enquiry further. The question then arises as to the ultimate disposal of fragmentary and disconnected records of this nature. Should they be at once published in their incomplete condition, or should they remain buried in the archives of the Research Institute until some approximation to finality is attained?

Neither of the criteria cited appears satisfactory to the writer; an arbitrary time limit to the period of obscurement is therefore adopted. After the lapse of five years, *i.e.*, within two triennial revisions of the programme of research, the more nearly related fragments are assembled in Record form.

2. In the volume on Indian Forest Coleoptera published in 1914 and in the departmental literature previous to that date, there is not found a single description or illustration by which the early stages of a species of beetle may be accurately identified. Until recent years this was also true of much of the European and North American literature on forest insects. Since it is in the early stages, particularly the larval stage, that a timber borer is chiefly met, the need for technical specific descriptions of larvae is obvious. The present record attempts technical descriptions of prionine larvae.

CHAPTER I

Anatomical Characters of Larvae of the Prionini.

Among the characters enumerated by Schiφdte, 1876, for larvae of the Prionini are the following : —

> Head transverse, sides of the head behind the epistoma joined by an elongate median sclerite, thence angular and divergent. The lower retractor muscles which withdraw the head, are inserted in a deep groove in front of the occipital foramen. Clypeus occupying the whole frontal margin. Labrum semicircular.

Webb, 1912, page 151, adopting Schiφdte's groups but raising them to family rank, gives the following characters for the family Prionidae :—

> "Head as broad as long, or broader than long, not deeply invaginated in the prothorax ...... Labrum large; clypeus large, filling frontal margin .... Head not flattened; sides of head not separated immediately behind the epistoma. Legs moderately long .... Sides of head behind epistoma fused for some distance, later separating, angulate. Head invaginated into prothorax almost to base of maxillae. Usually larvae of very large size."

Craighead, 1915, to whom we are indebted for a valuable study of the larval characters of the Prioninae, describes the general anatomical characteristics in considerable detail (*loc cit,* pages 8—12) and summarises the principal diagnostic features as follows :—

> "Head transverse, dorsal margins of epicranium behind front fused for some distance, later separating, angulate (*i.e.,* head emarginate behind). Inferior retractor muscles of head inserted in a deep fovea before cervical foramen.
>
> Mandibles wedge-shaped, cutting edge broadly emarginate, apex produced, acute.
>
> Epistoma produced in two triangular lobes, or a dentate carina over clypeus (except in *Parandra*); three epistomal setae on either side; front produced over epistoma, dentate or carinate.
>
> Clypeus thick, trapezoidal, as wide at base as epistoma. Labrum broad, thick, semicircular or cordate.
>
> Maxillae movable; cardo distinct; maxillary sclerite full, cushioned; palpifer not distinct, small; lacinia borne on stipes.
>
> Antennae strong, partially retractile.
>
> Legs short, stout, conical.
>
> Eusternum of prothorax partially or entirely, and the lateral zone,

distinct; coxal lobe large, surrounded by large hypopleurum; mesothoracic spiracle protruding into prothorax.

Lateral zone of abdomen protuberant only on last three segments; hypoleurum distinct; parascutal and coxal lobes large; spiracle in a well defined, elliptical region. Ambulatory ampullae bearing two transverse dorsal impressions and one ventral impression.

Ninth abdominal segment large, extended, never telescoped within the eighth."

An examination of the anatomical structure of a few Indian species of Prionini indicates that this group is not completely defined by the characters summarised above. Schiφdte appears to have based his definition almost exclusively on the structure of *Prionus coriarius* although he states, *loc cit,* page 398, that other species of prionine larvae from India, Borneo and South America do not differ from *Prionus coriarius* except in details of the sculpture of the head, formation of the ambulatory ampullae and other characters of minor importance. Webb and Craighead base their results on the larvae of North American Cerambycidae, the latter describing some 15 species of Prioninae.

As far as the Indian species examined by the writer have shown, the principal differences affect the shape of the head, epistoma and labrum and the disposition of the occipital foramen and tentorium.

The descriptions given by Heller, 1904, of larvae of the genera *Parandra, Ctenoscelis, Mallodon, Polyoza* from Brazil and a species of *Xixuthrus* from Ké Island, show similar points of difference when compared with larvae from Europe and North America.

For example, the head in the genera *Parandra, Mallodon, Polyoza, Xixuthrus, Macrotoma, Remphan, Logaeus* is not transverse but as long as broad, and even longer than broad.

The labrum is variable in form, *e.g.,* lancet-shaped, transversely elliptical, orbicular.

The epistoma does not project over the clypeus in *Parandra, Macrotoma.*[1]

The sides of the epicranium are fused for the whole dorsal surface of the head in *Macrotoma* and there is therefore no dorsal emargination.

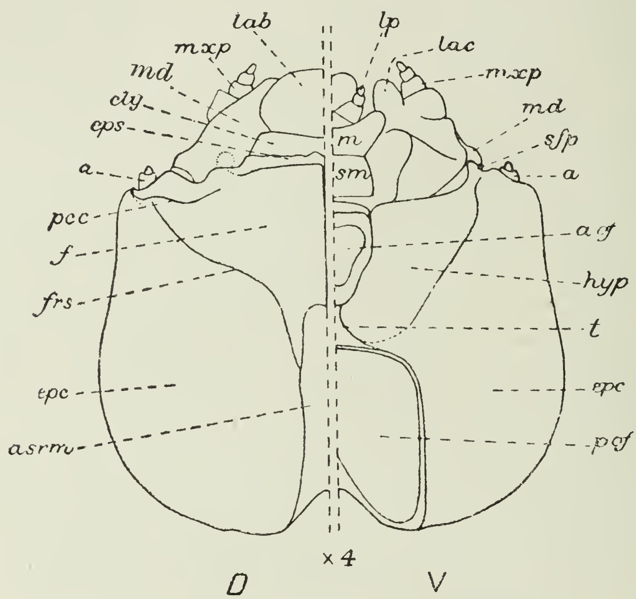
It is evident that in respect to the above-mentioned characters the Prionini closely approach the Asemini.

With regard to the two openings of the occipital foramen it is evident in all the larvae examined by the writer and in the Brazilian species

[1] This is also the case in certain species of prionine larvae from Africa as Craighead has pointed out, 1915, page 13.

described by Heller, that the smaller anterior opening is a definite perforation and not a furrow or fovea, and that it serves for the passage of the ventral nerve chord as well as the attachment of the inferior retractor muscles. The separation of the occipital foramen into two portions by an intervening tentorium would therefore appear to be one of the principal characteristics of the larvae of the Prionini; while far from peculiar to the group this feature appears to show valuable generic characters.

Text figure I shows the principal characters used in the descriptions of Cerambycoid larvae in the present and succeeding Records.



Text figure

Text figure 1. Head capsule of a Prionine larva. [terricolous species, *vide* p. 17]. semi-ventral, V, and semi-dorsal, D, aspects, showing areas and terms used in descriptions.

a = antenna.
aof = anterior opening of occipital foramen.
asrm = attachment of superior retractor muscles of head.
ly = clypeus.
epc = epicranium.
eps = epistoma.
f = front.
frs = frontal suture.
hyp = hypostoma.
lab = labrum.
lac = lacinia.
lp = labial palp.
m = mentum.
md = mandible.
mxp = maxillary palp.
pcc = post condylar carina.
pof = posterior opening of occipital foramen.
sfp = subfossal process.
sm = submentum.
t = tentorium.

CHAPTER II

The Economic Importance of the Sundri Borers.

Since 1908 various reports of attacks on sundri by boring insects have been received at the Forest Research Institute, usually accompanied by specimens. In almost every case a different insect was sent in and referred to as "the" sundri borer. Logs received in 1910 (F. L. 26G of 9th April 1910) yielded longicorn beetles, which were identified as *Diorthus cinereus*, White, *Derolus discicollis*, Gahan, *Gelonaetha hirta*, Fairm., and species of *Glenea* (Lamiidae) and *Chrysobothris* (Buprestidae). In Departmental Notes, I, page 420, is given an account of a platypodid beetle, *Diapus* (?) *heritierae*, Stebbing, which is referred to as the borer of sundri, *Heritiera littoralis* (=*Fomes*), and this beetle is subsequently mentioned on one or two occasions in the Annual Reports on Forest Administration for Bengal. In 1913 (F. L. 1106 of 4th November 1913) and again in 1914 (F. L. 1233 of 8th December 1913) specimens of sundri logs containing borers were received at Dehra Dun and from these was bred out a species of Platypodidae, *Crossotarsus squamulatus*, Chap., previously unrecorded from India. "Indian Forest Insects" which appeared in 1914 contains only one reference to an insect attacking sundri, *i.e.*, *Diapus? heritierae*, Stebbing (pp. 628-630). This species has since been shown to be identical with *Crossotarsus saundersi*, Chap. (Beeson, 1915, p. 297).

In February 1915 the Zoologist visited the Sunderbans with the object of deciding the relative importance of the species comprising the borer fauna of sundri, and incidentally to determine the effects, if any, of the cyclone of 1909 on the subsequent abundance of borers.

A cursory examination revealed no signs of localised insect attacks in coupes or in other parts of the forest, but an appreciable number of recently dead and dying trees was met with under certain conditions, (a) scattered in a narrow zone along the banks of *Khals* (creeks), and on the concave banks of most of the larger channels in the delta, and (b) in land around the margins of wet depressions and swamps. Omitting all the trees on the extreme edges of water channels, which had obviously died as a result of cutting back by the river, those trees were examined which were of very recent death, as indicated by the degree of wilting of the foliage. The majority of trees contained boring larvae of several species, but in a small proportion there were no traces of insect attack; in many cases it was possible to determine that the insects had attacked the tree *subsequent* to its death. The roots of a series of sample trees were exposed to a depth of 2-3 feet. *In all cases the roots were found to be diseased.*

The disease appears to be produced by a parasitic fungus, but no fructifications were found. The symptoms are evident in a rotten condition of the tap-root and main side-roots which is most marked just below soil level. As a rule the *shulas* (pneumatophores) are rotten within a circle round the base of the tree, the radius of which increases with the progress of the disease. The deeper portions of the tap-root and the outer portions of the shallow side-roots frequently show no sign of unhealthiness except in advanced stages, when a slight discoloration of the inner bark is visible. The dead trees usually occur in groups of 5 or 6, close together and of various ages corresponding to girths of 9 inches to 3 feet. The rot includes the whole of the heart-wood and is so sharply limited at the root collar that trees of two feet girth break off at soil level when pushed by the hand.

It is therefore concluded that the diseased condition of the roots of the sundri, which is concomitant with, and possibly resultant from, a waterlogged soil, is the primary cause of the death of the tree and that the borers are of secondary occurrence. There are no signs of an epidemic spreading from the marginal zone of diseased trees to the interior of the islands of forest.

The Borer fauna of Sundri. The principal species found boring into *Heritiera Fomes* in the Sunderbans are as follows :—

1. ANTHRIBIDAE . .	. *Ozotomerus maculosus*, Perr.
2. BOSTRYCHIDAE . .	. *Schistoceros malayanus*, Lesne.
3. BUPRESTIDAE . .	. *Chrysobothris* sp.
4. CERAMBYCIDAE .	. *Ceresium zeylanicum*, White, *Derolus discicollis*, Gahan, *Diorthus cinereus*, White, *Gelonaetha hirta*, Fairm., *Macrotoma plagiata*, Waterh.
5. LAMIIDAE . . .	. *Glenea* sp.
6. PLATYPODIDAE . .	. *Crossotarsus squamulatus*, Chap., *Crossotarsus saundersi* Chap., *Platypus uncinatus*, Bldfd. var nov.
7. SCOLYTIDAE . .	. *Progenius riehlii*, Eichh. *Xyleborus schlichii*, Steb.
and SIRICIDAE . .	. *Xyphydria* sp.

As regards relative abundance, the species of *Crossotarsus, Platypus, Xyleborus, Gelonaetha* and *Chrysobothris* are the most numerous.

Of the above listed species, data are recorded in this note only on *Macrotoma plagiata,* Waterh.

MACROTOMA PLAGIATA, *WATERHOUSE.*

Waterhouse, 1884, Ann. Mag. Nat. Hist. (5), XIV, p. 381.

Distribution.

Previously recorded from North India (Lameere, 1913, p. 28); present record from the Sunderbans forests, Bengal.

Food plants.

Heritiera Fomes, Buch. (Sundri).

DESCRIPTION OF THE STAGES.

I. THE ADULT.

[See Plate I, Fig. 8.]

General description. Dark brown, in parts almost black; surface of the body dull owing to very fine granulation.

Head with large prominent mandibles, much larger in ♂ than in ♀. *Antennae* not extending beyond the tip of the body, the 3rd joint in the ♂ equal in length to the 4th, 5th, and 6th, united. *Prothorax* transverse with the front margin less broad than the hind margin, the sides armed with very short, sharp spines; the dorsal surface of the prothorax more shining than the rest of the body, irregularly roughened and pitted in the ♀, and provided with two sub-triangular glossy patches separated from a transverse basal patch in the ♂. *Elytra,* dull granulate, parallel-sided, evenly rounded at the apex.

Length. 28-45 mm. $=1\frac{1}{2}$—$1\frac{3}{4}$ ins.

Technical description. Descriptions have been published by Lameere, 1903, and Gahan, 1906.

2. THE LARVA.

[See Plate I, Figs. 1—6.]

General description. The figure on Plate I shows the general appearance of the larva sufficiently well; its colour is cream-white and its texture smooth, shining and almost bare of hairs.

Technical description. Described from 12 larvae ex *Heritiera Fomes,* Sunderbans, Bengal, 9—12-II—1915; 18-XI—1915; 12-IX—1918; C. F. C. B. coll., RRD.5, BCR. 2.

HEAD (Fig. 4) with visible portion yellow; a spot on the epistomal margin at the apex of the median suture, a patch above the dorsal condyle, and a triangular area along the genal margin, black. Subquadrate, as broad as long, lateral margins curving outwards from the front and reaching the greatest breadth slightly behind the anterior border of the occipital foramen, thence broadly rounded to posterior margin. Dorsal margins of the epicranium fused for their whole length, not separating posteriorly, (*i.e.*, posterior emargination of foramen not visible from above).

Occipital foramen, subquadrate slightly broader than long, anteriorly transverse, sides rounded, and posterior emargination obtuse, dorsoventral. Anterior foramen subpyriform, hardly as long as intervening tentorium.

Epistoma transverse, roundly declivous, smooth, not projecting over clypeus. Post-condylar carina, concave, enclosing a depressed area, which is rugosely elevate over the condyle. Front sparsely punctuate and piliferous.

Clypeus transverse, trapezoidal (in one specimen, rectangular), about 3 times as broad as long, slightly convex, longitudinally striate near anterior margin.

Labrum subovate, longer than and almost as broad in the middle as the clypeus, convex, broadly fringed with red bristles, sparsely punctuate and piliferous posteriorly.

Ocelli absent.

Antennae extending beyond clypeus; basal joint subcylindrical, about 3 times as broad as 2nd joint, the latter nearly 3 times as long as broad; 3rd joint twice as long as broad, chestnut brown.

Mandibles rugose at base, becoming longitudinally striate beyond middle, apex shining.

Subfossal process, a very small pointed tubercle.

Ventral mouth parts, maxillary palpi relatively large, last joint obconical, longer than last joint of labial palpus; lacinia about equal in bulk to basal joint of palpi; ligula small.

PROTHORAX (Figs. 2, 3). Breadth about $^1/_5$ greater than that of 8th segment; strongly declivous, transversely impressed shortly behind anterior margin, which is matte and impunctate.

Pronotal plate weakly corneous, rectangular, nearly twice as broad as long, anteriorly more chitinised, smooth, sparsely punctate, the punctures with short hairs; a faint median line terminating in a shallow impression shortly behind the middle; posterior angles truncated by a small fold.

Sides of Prothorax subtriangular, more strongly chitinised, shining, impunctate in the centre.

PLATE I.

MACROTOMA PLAGIATA, Waterh.

Fig. 1. *Macrotoma plagiata*, Waterh. Larva, X $1\frac{1}{4}$, lateral view.

2. " " " Head and prothorax of larva, X 4, dorsal view.

3. " " " Head and prothorax of larve, X 4, ventral view.

4. " " " Head capsule of larva, X 4, ventral view.

5. " " " Ambulatory ampulla, of 5th abdominal segment, X 3, dorsal.

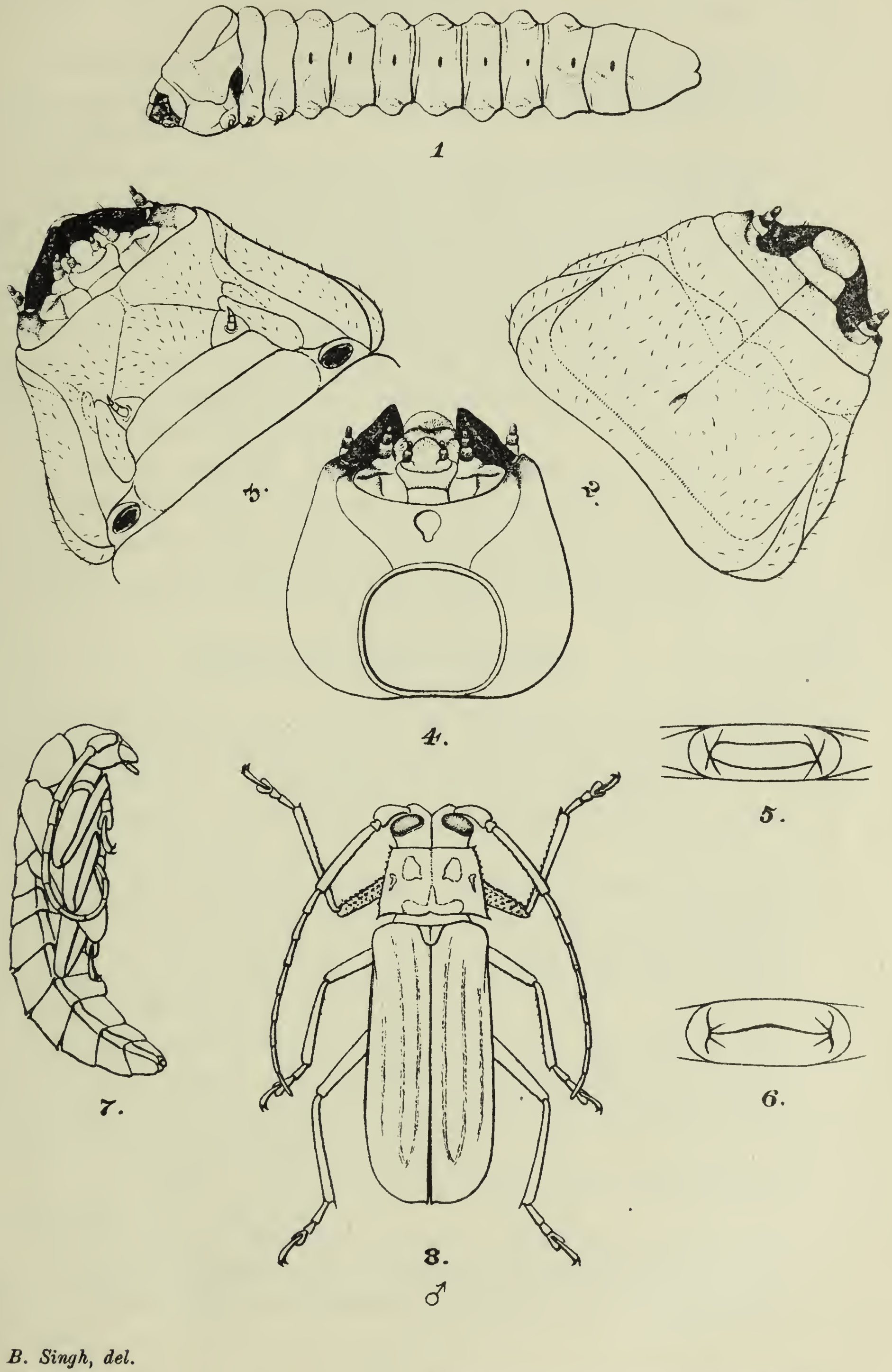
Fig. 6. *Macrotoma plagiata*, Waterh. Ambulatory ampulla, of 5th abdominal segment, X 3, ventral.

7. *Macrotoma crenata*, Fabr. Pupa, ♂, X 1, lateral view.

8. *Maorotoma plagiata*, Waterh. Beetle, ♂, X $1\frac{1}{2}$ dorsal view.

MACROTOMA PLAGIATA, WATERH.

PLATE I.



J. B. Singh, del.

1. Larva, lateral.
2. Head and prothorax, dorsal × 4.
3. „ „ ventral × 4.
4. „ Capsule, ventral. × 4.
5. Ambulatory ampulla 5th Seg. dorsal × 3.
6. „ „ „ ventral × 3.
7. Pupa, lateral.
8. Beetle, ♂ dorsal. × 1½.

[To face page 8.

Prosternum punctate, the punctures each with a short brown hair; eusternal and presternal region divided into 3 subequal triangular areas, by two oblique sutures.

Thoracic spiracle twice as long as that of first abdominal segment.

ABDOMEN. *Ambulatory ampullae* (Figs. 5, 6) smooth, dorsal series decreasing in breadth and increasing in length from the 1st to the 5th segments, the 5th and the 6th equal, 7th about equal to 4th; transverse impressions, parallel, very slightly curved posteriorly, truncated by two intersecting lateral impressions; ventral series with the progressive decrease less marked; the single transv rse impression arcuate forward; (in living larvae both dorsal and ventral surfaces are deeply grooved by a median longitudinal furrow).

8th abdominal segment cylindrical, equal in depth to preceding.

9th abdominal segment more than twice length of 8th.

Anus with the margin protuberant round a Y-shaped suture.

Length of largest larva 50 mm.; Breadth of thorax, 13 mm.

Notes on the Life History.

On the 9th February 1915, larvae of *M. plagiata* were collected by the writer in galleries in the large buttresses at the base of a dead sundri (S. T. 77); the larvae varied in length from 13 mm. to 37 mm.

A log [RRD. 5, B. C. R. 2] was despatched to Dehra Dun and caged on 10th March 1915.

In 1915 two male beetles emerged, one on the 30th June and the other on the 2nd July. A portion of the log was examined on 14th August 1915, and no living insects found in it. On 18th November 1915 the remaining portion was examined and three small larvae of *M. plagiata* removed, and the log replaced in the cage.

In 1916 two more beetles emerged, one ♀ on the 30th June and one ♂ on the 16th August. The experiment was discontinued on the 9th June 1917 in error, but emergence holes in the log show that one beetle emerged in 1917 subsequently to this date.

On 12th September 1918 the log was cut up and one living larva $2\frac{1}{2}$ inches long found in a gallery.

It is thus apparent that the life cycle of *Macrotoma plagiata* varies from one year to at least 5 years; the abnormally extended larval period is due in all probability to the desiccation of the wood on which the larva is feeding.

The larval galleries run irregularly through the heart-wood across and with the grain; they are fairly tightly packed with fibres and wood-dust; the diameter frequently reaches $\frac{3}{4}''$. There are no visible galleries between the sapwood and the bark.

The pupal chamber is an irregular excavation without definite shape, produced by a simple expansion of the larval gallery, which is padded with wood fibres to round off irregularities. It lies a short distance below the outer surface of the wood. The exit holes are subrectangular with rounded corners.

MACROTOMA CRENATA, *FABR.*

Fabr., 1801. Syst. Eleuth., II, p. 264.

Distribution.

Previously recorded from India,—Kashmir to south Bombay and Nepal to Calcutta; Ceylon; Burma.

Food Plants.

Bombax malabaricum, D. C. (Semul). *Tamarix articulata,* Vahl. (Farás.)

Quercus ilatata, Lindl. (Moru).

DESCRIPTION OF THE STAGES.

1. THE ADULT.

General description. Closely resembling *M. plagiata* but differing slightly in the shape of the glossy patches on the thorax of the ♂ and the relative length of the 3rd to 6th antennal joints. In the ♂ of this species the 3rd joint is equal in length to the 4th, 5th, and nearly half the 6th united.

Length 37—52 mm. = 17-16—2 $\frac{1}{16}$ inches.

Technical description. See Lameere, 1903 and Gahan, 1906.

2. THE LARVA.

Technical description. The available material is a larval head capsule taken from a pupal chamber in *Bombax malabaricum,* Saharanpur, U. P., 12-XII-1917, C. F. C. B. coll. RRD. 354, BCR. 188 and 2 nature larvae [Tubes 12, 36.]

The larva in form and coloring agrees very closely with *plagiata*. Nearly all the characters detailed above are apparently generic, but the following slight differences occur in *crenata*.

(*a*) a small tubercle on the epistoma near the inner termination of the postcondylar carina.

(*b*) the subfossal process in the form of a prominent sharp tubercle, much larger than that of *plagiata*.

(*c*) the tentorium shorter than the extreme length of the anterior foramen.

Breadth of head 10 mm.; length 10·5 mm.; length of larva 76 mm.; breadth of thorax 16 mm.

3. THE PUPA.

[See Plate I, Fig. 7.]

General shape as in Fig. 7.

Technical description. *Pronotum* formed as in adult but the margins are entire, not revealing the denticulations within; the posterior angles are acute; depressed areas occur on the disc corresponding to the imaginal markings.

Antennae with 3rd joint equal in length to the 4th, 5th, and half the 6th united, as in the adult.

Abdomen. Tergites adorned with numerous minute teeth; 5th segment with a median pair of carinate projections on the anterior and posterior margins; these processes are deeply concave on the lower surface and are formed by a pinching out and chitinisation of the pupal skin; similar paired processes occur on the posterior margin of the 4th segment and the anterior margin of the 6th segment; rudimentary teeth occur on the contiguous borders of the 3rd and 4th segments and the posterior border of the 6th segment. The projections on the anterior borders are directed anteriorly and those on the posterior borders, posteriorly, and apparently articulate with one another.

Length. 49 mm. one ♂ specimen. Tube No. 13.

Notes on the Life History.

Larvae were taken in a dead, tinder-dry tree of *Bombax malabaricum* (S. T. 32) at Pathri, Saharanpur Division, U. P., on 12-XII-17. The tree also contained numerous larvae of *Batocera* sp. A log was installed in the insectary (RRD. 354, BCR. 118) which yielded one female of *Macrotoma crenata* on 8-VIII-1918.

The galleries run irregularly in the wood deep in the core and are packed with a fairly compact mass of fibres, which are finer and dust-like in the early galleries; the diameter varies from $\frac{3}{4}$ to $1\frac{1}{4}$ inches.

The pupal chamber in an irregular excavation about $4'' \times 1\frac{3}{4}''$, containing loosely aggregated masses of fibres. The exit tunnel narrows very much towards the extremity, *i.e.*, from $1\frac{1}{4}''$ to $\frac{5}{8}''$, and runs almost horizontally to the outside.

The exit hole is subrectangular, $\frac{5}{16}'' \times \frac{9}{16}''$.

A female beetle collected by student Caldecourt at Suini, Chakrata Division, Jaunsar, U. P., is labelled " found in wood of felled oak tree (Moru), 2-VI-1916.

A female beetle was found at the base of a Sal stump by Range Officer P. C. Sinha, Gorakpur Division, U. P., on 23-VI-1918.

In 1905 Mr. T. R. Bell bred a long series of this species from the roots and trunk of Tamarix, at Karachi.

REMPHAN HOPEI, *WATERH.*

Waterhouse, 1836, Trans. Ent. Soc., London, I., p. 67, pl. 8, fig. 1.

Distribution.

India; Andaman Islands; North Toungoo; Pegu; Mergui Archipelago; Siam; Penang; Borneo.

Food Plants.

Dipterocarpus turbinatus, Gaertn. f. (Gurjan).

DESCRIPTION OF THE STAGES.

1. THE ADULT.

[See Plate II, Figs. 7, 8.]

General description. Variable in colour from reddish brown to dark brown but with the elytra always lighter in tint. Antennae with the 3rd joint equal in length to the 1st and spined. Prothorax with the sides converging in front and armed with numerous sharp spines on the edges. Surface of the pronotum and elytra smooth, without marked granular or pitted patches. Legs spiny; 1st joint of tarsus of front leg much larger than 2nd joint.

Length. 40-96 mm. Breadth. 12-30 mm.

Technical description. Lameere, 1903, and Gahan, 1906.

2. THE EGG.

[See Plate II, Figs. 5, 6.]

Technical description. Described from numerous specimens ex galleries in *Dipterocarpus turbinatus*, Andamans, RRD. 411.

Colour yellowish buff; ellipsoidal, 4·6 mm. × 2·3 mm.

Strongly constricted before apices; micropylar end not distinguishable; sculpture of chorion formed of a series of longitudinal and more or less sinuous ridges, which divide at irregular intervals into branches; the branches either (1) end freely in the interspace, or (2) rejoin the original ridge, or (3) join a neighbouring ridge; interspaces deeply pitted with oval pits, which extend transversely between the bordering carinae.

3. THE LARVA.

[See Plate II, Figs. 1-3.]

General description. Colour creamy yellow; head brown and black; smooth, sparsely hairy.

Technical description. Described from 6 larvae, ex *Dipterocarpus turbinatus*, Andamans, 20-IV-1918. D. F. O. coll. RRD. 411, and one larva ex *Dipterocarpus* sp, North Toungoo, Burma, 9-V-1917, D. F. O. coll. RRD. 274.

HEAD (Figs. 2, 3). with the visible portion light brown; epistoma, frontal ridge, postcondylar carina and fossa, mandibles, subfossal process, and oral margins, black. Capsule, subquadrate, a little longer than broad, sides widest near middle of occipital foramen, posterior angles separately rounded. Dorsal margins of epicranium fused medianly almost to posterior margin, groove of attachment of superior retractor muscles narrow, parallel-sided, occupying about 2-7th the length of the head.

Occipital foramen with anterior margin rounded, sides slightly divergent; posterior emargination subdorsal, bracket-shaped with the angle acute. Anterior foramen with the aperture depressed, triangular with concave sides and rounded angles.

Epistoma concave, projected over the clypeus and at the lateral angles which are subacute; front raised into a more or less denticulate, overhanging carina, which extends obliquely forward from behind the dorsal condyles and ends in two prominent teeth on either side of the median suture; Postcondylar carina broadly curved and finely aciculate at the edge enclosing a shallow impression which is radially striate.

Antennal scrobes elevated on inner side, broadly open postero-laterally. Antennae (contracted in all specimens examined) basal joint nearly twice as wide as 2nd joint; the latter cylindrical, short; 3rd joint conical, obliquely truncate at apex. Pleurostoma with a curved carina, posterior to which is a shallow furrow.

Subfossal process a prominent conical tooth.

Clypeus transverse, trapezoidal, narrowing slightly apically; $1\frac{3}{4}$ to 2 times as broad as long.

Labrum broadly ovate, flattened; at its greatest width as broad as the apical margin of the clypeus, and about $1\frac{1}{2}$ times as long as clypeus, margined anteriorly with reddish bristles, disc with fairly numerous punctures bearing longer hairs, median area bare.

Mandibles rugosely tuberculate in basal half, more or less striate and carinate in apical half, apex acute.

PROTHORAX. Breadth about $1\frac{2}{3}$ times that of segment 8; nearly twice as broad as long, declivous dorsally.

Pronotal plate, subrectangular, twice as broad as long, sides rounded, vermiculate in posterior half, transversally aciculate along median anterior border, sparsely punctate, the punctures piliferous; a median impressed line extends longitudinally for a short distance on either side of the anterior margin of the plate and terminates about the middle of the disc in an elongate group of punctures; an oblique impression runs from the middle of each side downwards to near the posterior margin.

Sides of Prothorax, deltoidal, convex, scantily punctate and pilose.

Prosternum, eusternal area not entirely distinct; an oblique suture traverses the posterior angle, in front of the leg; above each basal angle of the presternum a triangular rugose pad bounded behind by the evanescent intersternal suture.

Thoracic spiracle, ellipsoidal, $1\frac{1}{2}$ times as long as that on the 1st abdominal segment.

ABDOMEN. *Ambulatory ampullae,* without tubercles but narrowly aciculate along the sutures and occasionally punctate; dorsal series with the paired impressions parallel on the 3rd—6th segments, slightly curved backwards on the 7th segment; ventral series arched forwards on

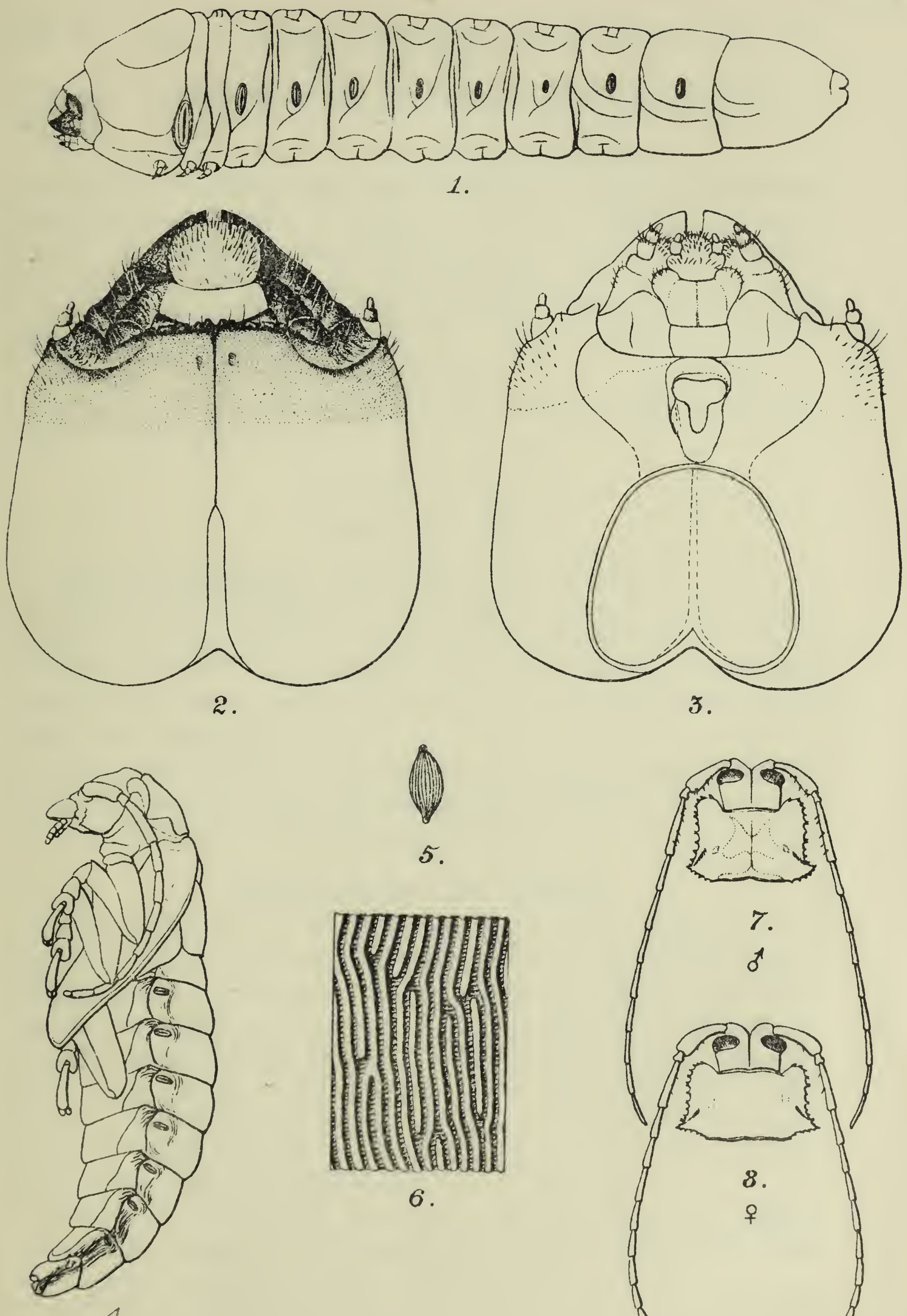
PLATE II.

Remphan hopei, Waterh.

Fig.	1.	*Remphan hopei,*		Waterh.	Larva, X 1, lateral view.
	2.	,,	,,	,,	Head capsule of larva X 4, dorsal view.
	3.	,,	,,	,,	Head capsule of larva, X 4, ventral view.
	4.	,,	,,	,,	Pupa, X 1, lateral view.
	5.	,,	,,	,,	Egg, X 2, lateral view.
	6.	,,	,,	,,	Egg, sculpture of chorion, X 16.
	7.	,,	,,	,,	Beetle, ♂, head and prothorax, X 1, dorsal view.
	8.	,,	,,	,,	Beetle, ♀, head and prothorax, X 1, dorsal view.

REMPHAN HOPEI, WATERH.

PLATE II.



J. B. Singh, del.

1. Larva, lateral.
2. Head capsule, dorsal × 4.
3. „ „ ventral × 4.
4. Pupa, lateral.
5. Egg × 2.
6. Egg sculpture × 16.
7. Head and prothorax of ♂ beetle.
8. „ „ ♀ „

[To face page 14.

segments 1-4, transverse on segments 5 and 6 and arched backwards on segment 7.

Segments 7, 8 and part of 9 with strong pleural folds.

8th abdominal segment, transversely striate, not so long as 7th and less than half as long as 9th.

Anal (9th) segment, rather broader than long, hemispherically rounded at apex, irregularly striate, coarsely punctate.

Anus situate on a circular boss, divided by a Y-shaped suture, the segments tangentially striate.

Length, 65—115 mm. = 2—4½ inches.

Largest larva; width of thorax 26 mm., width of abdomen 20 mm., length of anal segment 17 mm.

4. THE PUPA.

[See Plate II, Fig. 4.]

General description. General colour creamy white.

Technical description. Described from 2 pupae, ex *Dipterocarpus turbinatus*, Andamans, 20—IV-1918, D. F. O. coll. RRD. 411.

Head glabrous; dorsal surface of *prothoracic* and *abdominal* segments with numerous minute erect spines, mainly grouped in transverse zones; no carinate projections.

Appendages and ventral surface glabrous. Somites enclosing the anal and genital apertures, fleshy and terminating in corneous tubercles.

Length, 69 mm.; breadth of thorax, 23 mm.

Notes on the Life History.

The material sent by the Divisional Forest Officer, Andamans, is a portion of beam sawn from the heartwood of a tree of *Dipterocarpus turbinatus* after the attack of *Remphan hopei* was almost completed. The galleries of the borer are very closely crowded and, in comparison with those of most Indian heartwood borers, of enormous size; they run transversely through the heartwood and are much deeper than wide. The lumen of the gallery measures from 2¾ to 4¼ inches by ⅝ to 1 inch, *i.e.*, large enough to admit at once all the fingers of one's hand; they are loosely packed with coarse fibres.

The timber was received and caged on the 18th May 1918. Three male beetles emerged on 6th August, 6th October and 29th November 1918 respectively, and one female on the 2nd February 1919.

Two immature female beetles were collected with larvae and pupae on the 10th April 1918 at the time the material was despatched.

ACANTHOPHORUS SERRATICORNIS, *OLIV.*

Oliv., 1795, Ent. IV., no. 66, p. 14, pl. 9, fig. 33.

Stebbing (1914, p. 278) says of this species "In 1897 I discovered that the insects lived in the tree [*Shorea robusta*], the larvae tunnelling into the bast and sap-wood." He does not refer, however, to an interesting account of the larval habits published by M. H. Lucas in 1854 in the *Bulletin Entomologique, Séances de la Société entomologique de France,* pp. XLVII—XLVIII, of which the following translated extracts are worth noting.

This beetle is "fairly abundant in India and its larvae cause to the trees in which they live truly incalculable damage. This larva, 14—16 cm. long and 3 cm. wide, is of a testaceous yellow, with the head, the mouth parts, the antennae and the horny part which protects the spiracles, of a dark blackish brown. When this larva has attained to the desired size in order to change into a chrysalis, it forms a flattened oval cocoon 16—17 cm. long, by 8—9 cm. broad. When one examines this cocoon, destined to serve as the chamber for the metamorphoses both of the larva and the chrysalis, one notices that the materials which have been used in the construction of this habitation are long filaments of wood, packed one above the other, strongly interlaced, maintained and bound together by a sort of mortar composed of earth and which seems to have been previously moistened. Such is, in a few words, the exterior aspect of this habitation, but when one divides it into halves, one sees that the interior is the more elaborated of the two, and that the inside face instead of being rough like the exterior, is on the contrary, smooth.......The inner walls are smooth, polished, present no roughness and are so disposed that, not only is the larva not incommoded in its transformation, but also, the chrysalis meets with no obstacles when it arrives at the moment to change into the perfect insect.

"It is stated that these larvae and cocoons are not rare at Pondichéry where they destroy mulberry trees [mûriers]*; they make their way into the roots, which they bore in all directions, so that the latter are entirely destroyed and the tree finally perishes. The perfect insect, after having emerged from its shell by means of an opening which it makes in the lower part, pairs in the soil, and the female lays her eggs in the same cocoon. The larva lives 6 or 7 months before pupating. When breaking up one of these shells to examine the structure, I found a female of which the abdomen was filled with eggs: these latter are 8 to 9 mm. long and about 4 mm. broad; they exhibit the form of an elongated oval, and are lightly acuminate at both extremities."

In view of the above it is desirable to record the following descriptions of prionine larvae found boring into the roots of *Shorea robusta* and *Dalbergia sissoo,* and constructing earthen cells for pupation as, in all probability they are the larvae of *Acanthophorus* or allied genera.

* A popular publication, "The Marvels of Insect Life", 1913, states, p. 196, that the "grub is of enormous size and bores into the trunk of the mango tree." Fletcher "Some South Indian Insects," 1914, p. 320, states that the "larva is said to bore into mango."

A TERRICOLOUS PRIONINE LARVA.

[See Text figure 1, p. 4]

Technical description.—Described from 5 larvae, ex soil near roots of *Shorea robusta,* Buxa Division, Bengal 21—22-1-1915, C. F. C. B. coll.; ditto Gorakhpur Division, U. P., 17-1-1918, C. F. C. B. coll.

LARVA, very smooth and shining; pubescence sparse and silky.

HEAD, visible portions black.

Epistoma concave, projecting over clypeus, lateral angles obtusely rounded, two blunt teeth medianly; front raised in a low transverse carina, slightly arched forwards, notched in the middle behind which the median line is impressed, lateral angles tuberculate; Postcondylar impression well marked with the limiting carina broadly concave.

Antennal scrobes, elevate, thickened and truncate on inner sides, depressed and angularly emarginate postero-laterally. Pleurostoma with a well marked carina succeeded by a triangular furrow.

Subfossal process an acutely conical tooth.

Mandibles rugosely elevate at base; a conspicuous transverse impression in the median area, and a prominent rounded tubercle in front of the dorsal condyle.

Clypeus very narrow almost concealed at the epistome.

Labrum subcordate, gradually rounded from base to obtuse apex; posterior area dark brown, anterior area yellow and more densely pubescent.

PROTHORAX. Pronotal plate transverse, lateral borders rounded and slightly convergent anteriorly; median line faintly impressed; disk irregularly striate and punctate; anterior margin marked by a zone of stronger chitinisation. Prosternum with eusternal and presternal areas separated by a complete curved suture.

ABDOMEN. *Ambulatory ampullae,* with dorsal series of impressions subfusiform, ventral series all slightly curved forwards.

Pleural discs prominent, radially striate, circular on segments 1—3, elliptical on segments 4—5.

Length 80 mm. Breadth 15 mm.

Notes on the Life History.

Larvae agreeing generally with the foregoing description were found under the following conditions :—

1. At Rajabhatkhawa, Buxa Division, Bengal, in the soil close to the roots of dead sal trees [S. T. 58, 59] attacked by the root fungus,

Polyporus shoreae, on 21st and 22nd January 1915. C. F. C. B. Coll. [Tubes Prionini, 1, 2, 3.] One larva was found at a depth of one foot in an earthen cell, about two inches long, made of fragments of rotten wood cemented together with mud; the inside of the cell was lined with a thin smooth film of mud.

2. In March 1915 specimens of larvae [RRD. 4] were sent by the Conservator of Forests, Bengal, with the following note. "A clump of Sissoo was noticed (at Chilarpata, S. Borojhar Range, Buxa Division) in which most of the trees were dead. The roots of the two trees (one recently dead and the other not yet killed) were opened up to a depth of 5 feet. No trace of root fungus was found on the roots of either of the trees but a number of larvae were found in the soil round the roots and some of them were in the roots of the dead trees......."

Further specimens were despatched from this locality from a dead sissoo tree, girth 5′—1″, on 6th November 1915 [RRD. 54]. One larva arrived alive and an attempt was made to breed it out in rotten sissoo wood and earth. The insectary records [BCR. 31] are as follows. Between the 11th November and 23rd, the larva tunnelled irregularly in the soil, eventually confining its movements to circumambulation at the bottom of the glass jar in which it was closed. On the 25th January 1916, it was observed motionless at the bottom of the jar; on the 17th April it was noticed to have formed a cell in the soil and was apparently about to pupate. On the 3rd May it was found dead.

Seven more specimens were obtained from the roots of a sissoo, girth 4′—4″, in the same locality on the 20th January 1916 and despatched to Dehra Dun [RRD. 79]. Five larvae arrived in a living condition; they were kept under observation in the insectary in jars of earth and rotten wood [BCR. 49]. On the 17th April two larvae were found dead and by the 3rd May the remainder had died. Parasitic mites were numerous in this experiment.

3. In November 1915 a full grown larva of apparently the same species was taken by the Divisional Forest Officer, Gorakhpur, U. P., in a cell composed of fibres of rotten wood lined smoothly with a mud at the roots of a dying sal tree [RRD. 57]. The larva was kept under observation in the insectary [BCR. 32] under slightly different conditions. From the 23rd November to 20th December the larva was kept in an artificial chamber and the soil was constantly moistened. As mould developed it was transferred to dryer earth; during January the larva moved about on the surface of the soil without attempting to burrow and eventually becoming quiescent, died on the 12th April 1916.

Larvae were collected by the writer on 17th January 1918 at Bhelampur, Gorakhpur Division, U. P., in and near the roots of a dead sal tree affected by *Polyporus shoreae.* Some of the larvae had constructed smooth-walled cells of mud and fragments of wood. Two were brought alive in artificial mud-cells to Dehra Dun and a further attempt made to breed out the beetle. [RRD. 392, BCR. 225]. The larvae were observed alive on 16-III-18 but dead on 13-VI-18.

Summary. The larvae occur in and near the rotten roots of dead sal and shisham and construct earthen cells in the period November —January; they normally live until April before pupating. Their occurrence is apparently secondary to the death of the tree.

LOPHOSTERNUS HÜGELI, *REDTENBACH.*

Redtenbach, 1848, Hügel's Kaschmir, IV, 2, p. 550, pl. 28, fig. 1.

In Indian Forest Records, II (1909) Stebbing figures the larva of this species and gives a vague two-line description. The plate is reproduced as pl. XVII of Indian Forest Insects. The original larva from which the illustration was prepared is preserved in the Research Institute collection; on examination it proves to be that of a lamiid. There is no other material available.

In this connection I give the description of a prionid larva taken boring into dead *Quercus incana* at Ramgarh, Naini Tal Division, U. P., 6,000′ C. F. C. B., 18-VI-1914. [Pr. T. No. 31.]

HEAD (larva old with epistoma and mandibles very much worn); longer than broad; visible portion of head entirely black, transversely rugose behind epistomal ridge, median line impressed; on each side of the latter, opposite the prothoracic margin a raised semicircular rugose; boss; sides straight, posterior angles broadly rounded; *Occipital foramen* with front margin straight, slightly behind middle of head, anterior angles almost rectangular, sides very slightly curved; posterior emargination acute extending to the basal sixth of the dorsal surface; anterior foramen small, trapezoidal, sides converging posteriorly.

Epistoma projecting over clypeus, concave, lateral angles obtuse, with a low rounded transverse ridge, separated from the epistome by a shallow interrupted furrow, lateral angles obscure; *postcondylar impressions* of the epistome semicircular, margin carinate; *antennal scrobes,* subquadrate, raised in front and at the sides, depressed behind, pleural furrow well marked, obtusely angulate in middle; *subfossal process* obtuse, inconspicuous; no ocelli.

Clypeus retracted, anterior margin straight.

Labrum transverse, twice as broad as long, gradually rounded from base to anterior margin, the median part of which is straight; marginal fringe of bristles narrow; disc coarsely punctate.

Mandibles rugosities much worn; apices truncate.

Ventral mouth-parts distorted.

PROTHORAX. *Pronotal plate* trapezoidal, basal $1\frac{1}{4}$ times apical margin; sides straight for about the apical fifth, at which point a short oblique impression occurs, then curved outwards to the posterior angle; disc with a few large punctures and an impressed median line, transversely aciculate in anterior half, vermiculate posteriorly, and at sides; prosternal region wrinkled; eusterum separated from presternum by a forward-curving suture.

ABDOMEN. *Ambulatory ampullæ,* dorsal with two parallel furrows, ventral with one; no tubercles.

PARAPHRUS GRANULOSUS, *THOMS.*

Thomson, 1861, Essai Class. Ceramb., p. 329.

On pages 275—276 of "Indian Forest Insects," Stebbing refers to specimens of *Paraphrus granulosus,* Thoms. as taken by Mr. A. J. Gibson, I. F. S., in July 1909 in *Quercus ilex,* in Bashahr State, North-Western Himalayas. This material is represented by one specimen in the Research Institute collection bearing the following data: "specimen No. 50 of 23rd July 1909, from A. J. Gibson, Bashahr State, 23rd July 1909, Quercus ilex. No. nil, dated 18th July 1909. Paraphrus granulosus or n. sp.," all in Stebbing's handwriting. I have determined the specimen as *Lophosternus hügeli,* Redtenb.*

Stebbing's record, *loc cit,* pp. 275—276, should be transferred to the synonomy of the latter species. Lameere, 1913, p. 69, gives Bengal, Sylhet, Burma, Siam, Tonkin, as the distribution of *Paraphrus granulosus* and it is doubtful therefore if it occurs within the range of *Quercus ilex,* which extends from the western Himalyas towards Afghanistan.

LOGAEUS SUBOPACUS, *WATERH.*

Waterhouse, 1881, Ann. Mag. Nat. Hist. (5), VII, p. 458.

[Since the foregoing pages were sent to press I have been able, through the courtesy of Dr. F. H. Gravely, Assistant Superintendent, Zoological Survey of India, to examine material of this species.]

* *Vide* also Beeson, 1919, p. 146, footnote 15.

Distribution.

S. India, Travancore, Nilgiri Hills, Cochin.

Food Plant.

Unidentified.

DESCRIPTION OF THE STAGES.

1. THE ADULT.

Technical Description.—Lameere, 1910, and Gahan, 1906.

2. THE LARVA.

General Description.—Colour (of spirit specimens) brownish-yellow; head chestnut, with the fore margins black; cylindrical, slightly tapering, shining, apparently smooth but fine silky hairs are sparsely present.

Technical Description.—Described from 5 larvae 7821-20 in rotten wood, Kavalai, 1300-3000 feet, Cochin State, 24-27-IX-14, F. H. Gravely, coll.

HEAD.—Visible portions posteriorly suffused with chestnut, anterior margins, carinae, projections and mandibles black. Slightly longer than broad, lateral margins at first parallel than very feebly convex; posterior-lateral angles broadly rounded. Dorsal margins of epicranium fused to the posterior border, hence emargination of the occipital foramen not visible from above. Viewed dorsally, the posterior angles and margin form a continuous broad curve.

Occipital foramen with anterior margin transverse, anterior angles slightly rounded, lateral margins convergent posteriorly in a very gentle curve to the obtuse dorsoventral emargination. Anterior foramen sub-pyriform, longer than the intervening tentorium.

Epistoma concave, narrow, projecting over clypeus, lateral angles acutely prominent. Front raised in a sharp, transverse carina with the terminal angles acute and traces of two median dull teeth. Postcondylar carina broadly concave, coarsely striate.

Antennal scrobes very prominent and overhanging dorsally, projecting beyond the line of the epistoma. Antennae retracted, but the 3rd joint (? 2nd) is evidently long. cylindrical with convex distal surface on which is situate a minute tubercular supplementary joint. Pleurostomal carina prominent and sharply margined, external groove deep.

Subfossal process acutely conical.

Clypeus very narrow, sublinear, (? contracted in all specimens examined) with the tips of epistomal angles projecting beyond its anterior margin.

Labrum as broad as clypeus, almost semicircular.

Mandibles, a deep fossa just behind the median transverse carina is apparently constant.

PROTHORAX about $1\frac{1}{3}$ times as broad as long ; *pronotum* strongly declivious and narrowing anteriorly, most strongly chitinised in a transverse zone in front of the middle and in a small sharply bordered triangular patch on each lateral margin behind the middle ; median line well marked, occasionally incised, lateral margins impressed, lateral angles subrectangular, posterior margin sinuate.

Prosternum, eusterum small triangular, margins entire, presternum deeply bilobed.

Thoracic spiracle more than twice as long as abdominal spiracles, deepset.

ABDOMEN. *Ambulatory ampullae,* dorsal series simple, smooth, ventral series each with a V shaped mark composed of dark punctures or impressed dots, the apex of the V directed posteriorly. In some specimens this mark is scarcely visible on the anterior segments, but is always present on segments 6 and 7.

Segments 7, 8 and part of 9 with strong pleural folds. *Pleural discs* visible on segments 1—6, the last very feebly marked.

Anal (*9th*) *segment* twice as long as and broader than 8th segment, sides tapering from near the middle, to the *anus* which is formed by 3 prominent lobes meeting in a Y shaped suture of which the vertical branch is nearly equal in length to the other two united.

Length 42-62 mm. $= 1\frac{5}{8}$ to $2\frac{7}{16}$ inches.

Largest larva : width of thorax 11 mm. ; length of anal segment 12 mm.

3. The Pupa.

Technical Description.—Described from one specimen *loc. cit.*

Head with mouth parts individually distinct and the spine over the ventral condyle of the mandible prominent. Antennae with first joint asperulate, remaining joints minutely and sparsely tuberculate.

Pronotum transversely rugose-striate, the lateral spines enclosed in 3 separate lobes.

Dorsal surface of part of the meso-thorax, the meta-thorax and the abdominal segments with numerous short erect spines becoming coarser posteriorly; depressions corresponding to the lateral furrows of the ampullae, present.

Spiracles of segment 1 concealed, of segments 2—6 conspicuous, with strongly chitinised margins, of segments 7 and 8 rudimentary.

Appendages and ventral surface smooth; pleural region wrinkled.

Last segment with a dorsally directed pair of lobes, rugosely tuberculate at the tips.

Length 42 mm.; breadth of thorax, 12 mm.; breadth of abdomen, 13 mm.

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Note on the Mechanical Strength and Seasoning Properties of *Shorea robusta* (Sal) Timber.

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Introduction.

IN 1913 a Forest Memoir was published (Vol. II, Part II, Economic Series) dealing with the Economic Value of *Shorea robusta* (Sal). In the introduction to this publication it was stated that the records under sub-heads IX, Hardness and Toughness, and X Seasoning were incomplete, as under the former sub-head the necessary machinery to carry out the tests was not available, that the seasoning experiments had only been in progress a little over a year and that therefore definite results were not available. The enquiry has since been completed and the results are embodied in this note.

A reference to pages 8, 10 and 12 of the above-mentioned memoir will show that the tests for transverse strain, compression and shearing on specimens of Central Provinces Sal were carried out on specimens containing from 20 per cent. to 29 per cent. of moisture. It was therefore decided to retest both the Central Provinces' and United Provinces' Sal when thoroughly air dry. The results of the tests are given hereafter.

The tests were carried out by Babu Gyan Singh, under supervision of the writer.

I. Mechanical Properties of Sal (*Shorea robusta*) Timber.

The object of the tests carried out and recorded below was not only to determine the average strength of Sal timber to withstand strains of varying nature, but also to ascertain the effect on its strength, if any, when seasoning the timber in different ways, felling the trees at different periods of the year and growing the timber in different localities. Thus, some of the selected trees were felled in the winter and others at the commencement of, or during, the monsoon months. Then again, the logs were seasoned either in the open or under shade, or first immersed in water for several months and then dried on land. In all cases, after seasoning in the log, the timber was sawn into scantlings and allowed to season for a further period under shelter.

To meet the factor of locality, logs were obtained from trees grown in the Central Provinces or Southern Sal belt and also from the United Provinces or Northern Sal area, while a further differentiation was made by selecting trees grown in the plains and hills. And lastly, the above classes were sub-divided into trees of seedling and coppice origin. The results of the tests carried out are given below :—

(*i*).—RESULTS OF TESTS FOR TRANSVERSE STRAIN, ACROSS THE FIBRE, IN TONS PER SQUARE INCH.

Central Provinces Sal.

[NOTE.—Average of up to 6 tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	REMARKS.
1	2	3	4	5	6	7	8	9	10
1	Plains-grown Sal, from the Balaghat Division, Central Provinces.	Seedling .	Seasoned in the log for 7 years in the shade, then converted into scantlings and seasoned in shade for 8 months.	September	24″ × 2″ × 2″	13·95	1·47	6·61	Radial cut.
2	Do. .	Do. .	Do. . .	Do. .	Do. .	14·49	1·625	7·31	Oblique and tangential cuts.
3	Do. .	Do. .	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in shade.	Do. .	Do. .	22·20	1·63	7·34	Do.
4	Do. .	Do. .	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do. .	Do. .	25·05	1·57	7·06	Radial and oblique cuts.
5	Do. .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December .	Do. .	21·05	1·55	6·97	Do.
6	Do. .	Do. .	Seasoned in the log for 2 years and 9 months in open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	Do. .	25·95	1·65	7·42	Do.
7	Do. .	Coppice .	Do. . .	Do. .	Do. .	20·62	1·34	6·03	Do.
							AVERAGE .	6·96	

(*i*)—Results of tests for transverse strain, across the fibre, in tons per square inch—*contd.*

Central Provinces Sal—contd.

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	Remarks.
1	2	3	4	5	6	7	8	9	10
8	Hill-grown Sal, from the Balaghat Division, Central Provinces.	Seedling .	Seasoned in the log for 7 years in shade, then converted into scantlings and seasoned under cover for 8 months.	September .	24″ × 2″ × 2″	14·20	1·84	8·28	Radial and oblique cuts.
9	Do. .	Do. .	Do. . .	Do. .	Do. .	15·91	1·82	8·19	Radial and tangential cuts.
10	Do. .	Do. .	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in the shade.	Do. .	Do. .	25·18	1·46	6·57	Radial to oblique cut.
11	Do. .	Do. .	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do. .	Do. .	21·07	1·29	5·80	Radial and tangential cuts.
12	Do. .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December .	Do. .	19·48	1·69	7·61	Do.
13	Do. .	Do. .	Seasoned in the log for 2 years and 9 months in the open, then converted into scantlings and seasoned in shed for 1 year and 3 months.	June .	Do. .	22·25	1·61	7·24	Radial or tangential cut.
14	Do. .	Coppice .	Do. . .	Do. .	Do. .	20·20	1·51	6·79	Radial.
							Average .	7·21	

(*i*)—RESULTS OF TESTS FOR TRANSVERSE STRAIN, ACROSS THE FIBRE, IN TONS PER SQUARE INCH—*contd.*

United Provinces Sal.

[NOTE.—Average of up to 6 tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	REMARKS.
1	2	3	4	5	6	7	8	9	10
15	Plains-grown Sal, from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	24″ × 2″ × 2″	21·69	1·73	7·78	Radial and tangential cuts.
16	Plains-grown Sal, from the Chakaha Range, of the Haldwani Division, United Provinces.	Do. .	Do. . .	Do. .	Do. .	19·36	1·56	7·02	Do.
17	Plains-grown Sal, from the Haldwani Division, United Provinces.	Do. .	Seasoned in the log for 4 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	Do. .	18·11	1·58	7·11	Radial, tangential and oblique cuts.
18	Plains-grown Sal, from the Kheri Division, United Provinces.	Seedling .	Seasoned in the log for 3 years and 8 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	Do. .	18·68	1·61	7·24	Radial and tangential cuts.
19	Plains-grown Sal, from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	20·38	1·95	8·77	Do.
20	Plains-grown Sal, from the Lakhmanmandi Block, of the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	Do. .	23·60	1·52	6·84	Do.
			AVERAGE .	..	..	..	..	7·46	

(*ii*)—RESULTS OF TESTS FOR TRANSVERSE STRAIN, ACROSS THE FIBRE, IN TONS PER SQUARE INCH—*contd.*

United Provinces Sal—contd.

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	
1	2	3	4	5	6	7	8	9	10
21	Hill-grown Sal, from the Laibor Block of the Haldwani Division, United Provinces.	Not known .	Seasoned in log for 3 years and 9 mon in the open, then converte into scantlings and seasoned in shade for 1 year and 3 months.	Jun .	24″ × 2″ × 2″.	18·53	1·69	7·61	Radial and tangential cuts.
22	Hill-grown Sal, from the Chini Block of the Haldwani Division, United Provinces.	Do. .	Do. . .	Do. .	Do. .	19·16	1·58	7·11	Do.
23	Do. . .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	15·42	2·05	9·22	Radial, oblique and tangential cuts.
24	Hill-grown Sal, from the Haldwani Division, United Provinces.	Do.	Do. . . .	Do. .	Do. .	17·87	1·72	7·74	Radial and tangential cuts.
			AVERAGE .	..	..	..	..	7·92	

Conclusions arrived at from tests for Transverse Strain—

(1) Taking the results as a whole, they are extraordinarily uniform; thus the averages for Central Provinces and United Provinces, plains-grown Sal, are 6·96 and 7·46 tons and those of hill-grown Sal 7·21 and 7·92 tons per square inch, respectively. Six years ago, similar tests were carried out on timber cut from the same localities, the corresponding results for Central Provinces and United Provinces Sal being 7·298 and 7·215 tons per square inch, respectively. It may therefore be taken as an established fact that the transverse strength of Sal timber is approximately 7 tons per square inch.

(2) The United Provinces Sal is slightly stronger than that from the Central Provinces, though for working purposes the difference is insignificant.

3) Logs were felled in September, December and June, in the same localities and seasoned in correspondingly different ways. The results are, therefore, comparative. The timber felled in September gave 7·14 tons per square inch, that felled in December gave 7·42 tons per square inch and that in June 7·13 tons per square inch. The timber felled when the sap was down was the strongest.

(4) There is no marked difference in the strength of timber which has been seasoned on land, and that from logs first immersed in water and then seasoned on land. It is true that the specimens recorded under serial No. 11, which were cut from a log immersed in water for $2\frac{1}{2}$ years, only showed 5·80 tons per square inch, on the other hand specimens cut from a similarly treated log and recorded under serial No. 4 showed 7·06 tons per square inch.

(5 The only example of coppice grown timber gave 6·03 tons per square inch. Further tests are necessary to ascertain whether this class of timber is uniformly less strong than timber of seedling origin.

(ii)—RESULTS OF TESTS FOR COMPRESSION, PARALLEL OT THE GRAIN, IN TONS PER SQUARE INCH.

Central Provinces Sal.

[NOTE.—Average of 6 tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	REMARKS.
1	2	3	4	5	6	7	8	9	10
1	Plains-grown Sal, from the Balaghat Division, Central Provinces.	Seedling .	Seasoned in the log for 7 years in the shade, then converted into scantlings and seasoned in the shade for 8 months.	September	Bobbin, $1\frac{1}{8}''$ diameter in centre, with $1\frac{1}{2}''$ diameter ends and $3''$ long.	12·70	3·56	3·56	Straight grained.
2	Do. . .	Do. .	Do. . . .	Do. .	Do. .	13·10	3·54	3·54	Do.
3	Do. . .	Do. .	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in shade.	Do. .	Do. .	13·43	3·57	3·57	Do.
4	Do. . .	Do. .	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do. .	Do. .	13·36	3·83	3·83	Do.
5	Do. .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	13·35	3·89	3·89	Do.

(	Do.	Do.	Seasoned in the log for 2 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June	Do.	11·85	4·59	4·59	Do.
7	Do.	Coppice	Do.	Do.	Do.	10·65	4·32	4·32	Do.
			AVERAGE	..	..	..	3·90	3·90	
8	Hill-grown Sal, from the Balaghat Division, Central Provinces.	Seedling	Seasoned in the log for 7 years in shade, then converted into scantlings and seasoned under cover for 8 months.	September	Do.	13·30	4·36	4·36	Straight fibre.
9	Do.	Do.	Do.	Do.	Do.	13·35	3·84	3·84	Do.
10	Do.	Do.	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in the shade.	Do.	Do.	13·00	3·39	3·39	Do.
11	Do.	Do.	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do.	Do.	13·09	2·57	2·57	Do.
12	Do.	Do.	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do.	11·40	4·82	4·82	Do.
13	Do.	Do.	Seasoned in the log for 2 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June	Do.	12·00	3·96	3·96	Do.
14	Do.	Coppice	Do.	Do.	Do.	11·49	4·44	4·44	Do.
			AVERAGE	..	..	..	3·91	3·91	

(*ii*)—RESULTS OF TESTS FOR COMPRESSION, PARALLEL TO THE GRAIN, IN TONS PER SQUARE INCH.

United Provinces Sal.

[NOTE.—Average of 6 tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in Inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	REMARKS.
1	2	3	4	5	6	7	8	9	10
15	Plains-grown Sal, from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	Bobbins, $1\frac{1}{8}''$ diameter in centre, with $1\frac{1}{2}''$ diameter ends, and $3''$ long.	11·93	4·11	4·11	Straight fibre.
16	Plains grown Sal, from the Chakaha Range, of the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	Do. .	11·34	4·02	4·02	Do.
17	Plains-grown Sal, from the Haldwani Division, United Provinces.	Do. .	Seasoned in the log for 4 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	Do. .	10·47	3·84	3·84	Do.
18	Plains-grown Sal, from the Kheri Division, United Provinces.	Seedling .	Seasoned in the log for 3 years and 8 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	Do. .	12·94	3·75	3·75	Do.

19	Plains-grown Sal, from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do.	10·56	4·71	4·71	Straight fibre.
20	Plains-grown Sal, from the Lakhmanmandi Block, of the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	Do. .	10·67	3·55	3·55	Do.
			AVERAGE .	..	..	..	3·99	3·99	
21	Hill-grown Sal, from the Laibor Block of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	Bobbins, 1⅛″ diameter in centre, with 1½″ diameter ends, and 3″ long.	11·41	4·19	4·19	Do.
22	Hill-grown Sal, from the Chini Block of the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	Do. .	12·96	3·64	3·64	Do.
23	Do. . .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	12·51	5·12	5·12	Do.
24	Hill-grown Sal, from the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	Do. .	10·93	4·36	4·36	Do.
			AVERAGE .	..	..	..	4·33	4·33	

The conclusions arrived at from the compression tests, carried out parallel to the grain, are as follows :—

(1) There is no difference in the strength of the timber seasoned in the log in the open and under shade though, as in the case of tests for transverse strain, the timber from logs immersed in water (serial No. 11) has been adversely affected and shows a falling off in strength.

(2) Trees were felled in September, December and June, which months correspond respectively with the end of the growing period, the period of rest when the sap is down and the commencement of the growing period. The results obtained are strictly comparative, as the trees were felled in the same localities at each period of the year and the timber was seasoned in correspondingly different ways, while the results are based on 138 tests, on timber containing in every instance less than 13·43 per cent. of moisture. The timber felled in September showed a strength of 3·58 tons per square inch, that felled in December showed a strength of 4·41 tons per square inch and that felled in June gave 4·09 tons per square inch. The timber therefore, which was felled when the sap was down was considerably the strongest, and this fact is corroborated by the tests for transverse strain.

(3) The results show no difference between plains and hill-grown Sal from the Central Provinces, but a considerable difference in that from the United Provinces, the hill-grown Sal being as much as 0·34 tons per square inch stronger than the former. The United Provinces Sal on an average is slightly stronger than that from the Central Provinces.

(4) From the above records an average of 4 tons per square inch may be taken as the compression strength of Sal timber.

(*iii*)—RESULTS OF TESTS FOR SHEARING, PARALLEL TO THE FIBRE, IN TONS PER SQUARE INCH.

Central Provinces Sal.

[NOTE.—Average of 6 tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	REMARKS.
1	2	3	4	5	6	7	8	9	10
1	Plains-grown Sal from the Balaghat Division, Central Provinces.	Seedling .	Seasoned in the log for 7 years in the shade, then converted into scantlings and seasoned in shade for 8 months.	September	Two planes of cleavage, ¾″ × 2″ = 3 square inches, shearing surface.	12·70	2·77	0·92	Plane of cleavage was radial, or at right angles to the annual rings.
2	Do. . .	Do. .	Do. . . .	Do. .	Do. .	13·10	2·28	0·76	Do.
3	Do. . .	Do. .	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in shade.	Do. .	Do. .	13·43	2·36	0·79	Plane of cleavage was tangential to the annual rings.
4	Do. . .	Do. .	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do. .	Do. .	13·36	3·12	1·04	Do.
5	Do. . .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	13·35	3·13	1·04	Plane of cleavage oblique to annual rings.
6	Do. . .	Do. .	Seasoned in the log for 2 years and 9 months in open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	Do. .	11·85	2·93	0·98	Do.
7	Do. . .	Coppice .	Do. . . .	Do. .	Do. .	10·65	3·32	1·11	Do.
			AVERAGE .	..	..	..	2·84	0·95	

(iii)—RESULTS OF TESTS FOR SHEARING, PARALLEL TO THE FIBRE, IN TONS PER SQUARE INCH.

Central Provinces Sal—contd.

[NOTE.—Average of 6 tests in each case]—*contd.*

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing.	Actual weight applied to cause fracture, in tons.	Tons per square inch.	REMARKS.
1	2	3	4	5	6	7	8	9	10
8	Hill-grown Sal from the Balaghat Division, Central Provinces.	Seedling	Seasoned in the log for 7 years in shade, then converted into scantlings and seasoned under cover for 8 months.	September	Two planes of cleavage, ¾″ × 2″ = 3 square inches shearing surface.	13·30	3·05	1·02	Plane of cleavage oblique.
9	Do.	Do.	Do.	Do.	Do.	13·35	2·69	0·89	Plane of cleavage radial.
10	Do.	Do.	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in the shade.	Do.	Do.	13·00	1·74	0·58	Plane of cleavage tangential.
11	Do.	Do.	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do.	Do.	13·09	2·21	0·74	Do.
12	Do.	Do.	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do.	11·40	2·85	0·95	Do.
13	Do.	Do.	Seasoned in the log for 2 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June	Do.	12·00	3·26	1·09	Plane of cleavage oblique and tangential.
14	Do.	Coppice.	Do.	Do.	Do.	11·49	3·50	1·17	Plane of cleavage oblique.
			AVERAGE	..	..	..	2·76	0·92	

United Provinces Sal.

15	Plains-grown Sal from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	Two planes of cleavage, $\frac{3}{4}'' \times 2''=3$ square inches shearing surface.	11·93	2·84	0·95	Plane of cleavage oblique
16	Plains-grown Sal from the Chakaha Range of the Haldwani Division, United Provinces.	Do. .	Do.	Do. .	Do. .	11·34	2·48	0·83	Do.
17	Plains-grown Sal from the Haldwani Division, United Provinces.	Do. .	Seasoned in the log for 4 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	Do. .	10·47	2·10	0·70	Plane of cleavage tangential.
18	Plains-grown Sal from the Kheri Division, United Provinces.	Seedling .	Seasoned in the log for 3 years and 8 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	Do. .	12·94	2·89	0·96	Plane of cleavage oblique.
19	Plains-grown Sal from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	10·56	2·96	0·99	Do.
20	Plains-grown Sal from the Lakhmanmandi Block of the Haldwani Division, United Provinces.	Do. .	Do. . .	Do. .	Do. .	10·67	2·42	0·81	Plane of cleavage, 3 specimens radial and 3 tangential.
			AVERAGE	..	..	..	2·61	0·87	

(*iii*)—Results of tests for shearing, parallel to the fibre, in tons per square inch.

United Provinces Sal—contd.

[Note.—Average of 6 tests in each case—*contd.*]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Size of piece tested, in inches.	Percentage of moisture in timber at time of testing	Actual weight appied to cause fracture, in tons.	Tons per square inch.	Remarks.
1	2	3	4	5	6	7	8	9	10
21	Hill-grown Sal from the Laibor Block of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Jun e .	Two planes of cleavage, $\frac{3}{4}'' \times 2'' = 3$ square inches shearing surface.	11·41	3·06	1·02	Plane of cleavage tangential.
22	Hill-grown Sal from the Chini Block, of the Haldwani Division, United Provinces.	Do, .	Do.	Do. .	Do. .	12·96	2·42	0·81	Do.
23	Do. .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	Do. .	12·51	2·85	0·95	Plane of cleavage oblique.
24	Hill-grown Sal from the Haldwani Division, United Provinces.	Do. .	Do.	Do. .	Do. .	10·93	3·24	1·08	Plane of cleavage tangential.
			Average .	..	..	..	2·89	0·96	

The conclusions arrived at from the shearing tests, carried out parallel to the grain, are as follows :—

(1) There is no difference in the strength of timber seasoned in the open or under shade, nor is there any marked difference in timber seasoned on land or after immersion in water.

(2) Trees were felled in September, December and June, and shearing tests carried out on timber of each class. As was the case with tests for transverse and compression strains, the December felled timber was strongest, amounting to 0·97 tons per square inch. That cut in June was nearly as strong amounting to 0·96 tons per square inch, and that from September cut logs 0·84 tons per square inch. The differences in strength of timbers cut at different seasons of the year are not so marked in the case of shearing tests as in those for transverse strain and compression, as the interlocked nature of the fibre is the main factor in determining its strength to withstand shearing.

(3) There is practically no difference in the strength of the timber grown in the plains or hills to withstand shearing, either in the case of Central Provinces or United Provinces Sal.

(4) From the results recorded above the strength of Sal to withstand shearing may be taken as 0·90 tons per square inch.

(*iv*).—RESULTS OF TESTS FOR HARDNESS, CALCULATED ON THE NUMBER OF POUNDS REQUIRED TO PRESS IN A STEEL SEMI-SPHERE OF 0·444″ DIAMETER=$\frac{1}{4}$ SQUARE INCH BASAL AREA, COMPLETELY INTO THE TIMBERS ON THE (*i*) RADIAL, (*ii*) TANGENTIAL AND (*iii*) CROSS SECTION SURFACES.

Central Provinces Sal.

[NOTE.—Average of four tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Percentage of moisture in timber at time of testing.	ACTUAL WEIGHT APPLIED TO PRESS IN A ·444″ DIAM SEMI-SPHERE COMPLETELY INTO THE SPECIMENS.			REMARKS.
						On Radial surface, in lbs.	On Tangential surface, in lbs.	On Cross sections, in lbs.	
1	2	3	4	5	6	7	8	9	10
1	Plains-grown Sal from the Balaghat Division, Central Provinces.	Seedling .	Seasoned in the log for 7 years in the shade, then converted into scantlings and seasoned in shade for 8 months.	September	11·80	1,600	1,524	1,584	
2	Do. . .	Do. .	Do. . . .	Do. .	12·32	1,525	1,511	1,374	
3	Do. . .	Do. .	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in shade.	Do. .	12·78	1,870	1,814	1,657	
4	Do. . .	Do. .	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do. .	12·81	1,921	1,844	1,684	
5	Do. .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	12·61	1,904	1,994	1,764	

6	Do.	Do.	Seasoned in the log for 2 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June	12·31	1,897	1,895	1,617
7	Do.	Coppice.	Do.	Do.	11·70	2,321	2,097	2,000
			AVERAGE	..	..	1,863	1,811	1,669
8	Hill-grown Sal, from the Balaghat Division, Central Provinces.	Seedling	Seasoned in the log for 7 years in shade, then converted into scantlings and seasoned under cover for 8 months.	September	13·01	1,961	2,177	1,717
9	Do.	Do.	Do.	Do.	12·83	2,014	2,272	1,871
10	Do.	Do.	Seasoned in the log for 7 years in the open, then converted into scantlings and seasoned for 8 months in the shade.	Do.	13·97	1,432	1,340	1,329
11	Do.	Do.	Log immersed in water for 2 years and 7 months, dried on land in open for 4 years and 5 months, then converted into scantlings and seasoned in shade for 8 months.	Do.	11·40	1,789	1,682	1,646
12	Do.	Do.	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	12·15	2,177	2,209	1,825
13	Do.	Do.	Seasoned in the log for 2 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June	12·35	1,947	1,699	1,611
14	Do.	Coppice	Do.	Do.	11·82	1,561	1,815	1,395
			AVERAGE	..	..	1,840	1,885	1,628

(*iv*)—Results of tests for hardness, calculated on the number of pounds required to press in a steel semi-sphere of 0·444″ diameter$=\frac{1}{4}$ square inch basal area, completely into the timbers on the (*i*) radial, (*ii*) tangential and (*iii*) cross section surfaces.

United Provinces Sal.

[Note—Average of four tests in each case.]

Serial No.	Locality where grown.	Origin of timber.	Method of seasoning.	Time of felling.	Percentage of moisture in timber at time of testing.	Actual weight applied to press in a ·444″ diam semi-sphere completely into the specimens. On Radial surface, in lbs.	On Tangential surface, in lbs.	On Cross sections, in lbs.	Remarks.
1	2	3	4	5	6	7	8	9	10
15	Plains-grown Sal, from the Jaulasal Range, of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	11·50	1,924	1,836	1,654	
16	Plains-grown Sal, from the Chakaha Range of the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	12·04	1,671	1,829	1,564	
17	Plains-grown Sal from the Haldwani Division, United Provinces.	Do. .	Seasoned in the log for 4 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	12·39	1,675	1,865	1,592	
18	Plains-grown Sal from the Kheri Division, United Provinces.	Seedling .	Seasoned in the log for 3 years and 8 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	Do. .	13·56	1,720	1,814	1,524	

19	Plains-grown Sal from the Jaulasal Range of the Haldwani Division, United Provinces.	Not known	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	11·68	1,996	2,152	1,812
20	Plains-grown Sal, from the Lakhmanmandi Block, of the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	11·80	1,376	1,587	1,355
			AVERAGE .	..	..	1,727	1,847	1,583
21	Hill-grown Sal from the Laibor Block of the Haldwani Division, United Provinces.	Not known .	Seasoned in the log for 3 years and 9 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	June .	11·75	1,994	1,994	1,599
22	Hill-grown Sal from the Chini Block of the Haldwani Division, United Provinces.	Do. .	Do. . .	Do. .	12·16	1,711	1,686	1,420
23	Do. . .	Do. .	Seasoned in the log for 4 years and 3 months in the open, then converted into scantlings and seasoned in shade for 1 year and 3 months.	December	11·94	2,259	2,196	2,101
24	Hill-grown Sal from the Haldwani Division, United Provinces.	Do. .	Do. . . .	Do. .	12·16	2,182	2,334	1,920
			AVERAGE .	..	..	2,036	2,052	1,760

Conclusions arrived at from Hardness tests.

(1) Generally speaking, timber presents a harder surface on the cross than on the radial or tangential sections, except in the case of some very hard timbers. From the tests carried out on Sal it will be seen that the radial and tangential surfaces are harder than that of the cross section, and therefore this timber is one of the exceptions to the rule.

As compared with other timbers, taking the average of *Shorea robusta* as 1,800 lbs. on the radial or tangential surfaces, *Shorea obtusa* is 3,000 lbs. and *Shorea assamica* 1,450 lbs. Teak is 1,200 to 1,400 lbs. according to locality in which it is grown. Sal should therefore be classed as a hard timber, if teak is classed as moderately hard and *Shorea obtusa* as very hard timber.

(2) There is little difference between Hill and Plains-grown Sal from the Central Provinces, though a marked difference in that from United Provinces, where Hill-grown timber is considerably harder than that from the plains.

(3) There is no difference in timber seasoned by different methods.

II. Seasoning Properties of Sal (*Shorea robusta*) Timber.

(*i*) *RATE OF SEASONING.*—Sal timber when seasoned under shelter, in small pieces, dries out moderately quickly; thus, the hand specimens prepared to determine the specific gravity of the timber, and taken from logs cut in various districts of the United Provinces and Central Provinces, dried out in about a year. The specimens, when first examined, contained varying percentages of moisture, the highest recorded being 36·25 per cent.; within 14 months all contained less than 10 per cent., one being as low as 7·80 per cent. Sal timber, on the other hand, absorbs moisture, to a surprising extent when the atmosphere is damp, even when it is fairly green; thus a Sal log laid down to season on the 16th May 1911 with 32·45 per cent. of moisture, contained 40·60 per cent. on the 8th April 1914, and this owing to a heavy fall of rain a day or two before taking the latter reading.

When Sal timber is seasoned in the log or in large sizes it dries out extremely slowly, especially when left in the open, and only slightly less slowly when under shelter; in fact, unless cut into small scantlings or boards, it appears never to attain the dryness of most other Indian timbers. In proof of this statement, the following figures are given of moisture percentages in a few of the logs laid down to season under different conditions :—

Serial No.	How seasoned.	Record of moisture contents while in log.							Record of moisture contents on scantlings.
		5th August 1911.	6th July 1912.	8th April 1913.	23rd July 1913.	31st March 1914.	12th December 1915.	31st October 1916.	Percentage of moisture after conversion into scantlings and seasoning in shed for 15 months.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
	Plains-grown Central Provinces Sal.								
1	Seasoned in log under thatched roof.	32·45	42·89	39·76	33·45	40·60	27·20	19·72	13·95
2	Seasoned in log under tin roof .	32·45	35·29	35·61	35·11	33·64	17·90	16·70	14·49
3	Seasoned in log in open . .	37·75	37·14	37·38	34·23	48·36	42·26	32·44	22·20
4	Log immersed in water from 5th August 1911 to 8th April 1913, then seasoned on land in the open.	37·75	40·37	44·85 Taken out of water on this date.	46·33	43·67	39·38	31·10	25·05

It will be seen that those logs which were seasoned under cover dried out to 19·72 per cent. and 16·70 per cent. of moisture in a little over 5 years, whereas those seasoned in the open still contained 32·44 per cent. and 31·10 per cent. of moisture respectively at the end of the same period. The figures also clearly show that this timber readily reabsorbs moisture, especially during the monsoon.

(*ii*) *RESULTS OF SEASONING EXPERIMENTS.*—Sal timber develops cracks while seasoning, the most common type being heart or star-shakes and surface cracks. The major cracks are generally fairly straight, large and few in number, while the surface shakes invariably result in a network of alternate oblique cracks in echelon, following the interlocked grain of the timber. This is typical of most Dipterocarp timbers and markedly so in Sal, and is more prevalent in the older timber of large logs than in the outer zones of the heart-wood.

The various methods adopted for seasoning Sal were as follows :—

(*i*) Logs seasoning *under shelter* in the log for 7 years, followed by conversion and seasoning the scantlings under cover for a further period of 15 months :—

(*a*) The shelter being a thatched roof.

(*b*) The shelter being a tin roof.

(*ii*) Logs seasoning *in the open* for 7 years, followed by conversion and seasoning the scantlings under shelter for a further period of 15 months.

(*iii*) Logs immersed in water for 2 years and 7 months, then on land in the open for 4 years and 5 months, followed by conversion into scantlings and seasoning under shelter for a further period of 8 months.

(*iv*) Logs from trees felled in June and December, seasoned for from 3 years and 9 months to 4 years and 9 months in the open, followed by conversion and a further period of seasoning in scantling shape for 8 to 15 months. The logs were inspected at least once a year, and diagrams prepared of the state of each end of each log, in order to maintain a continuous record of their condition and the rate at which they developed cracks. The following notes record the condition of the timber at the time of the last inspection :—

Experiment—

(*i*) (*a*) Logs seasoned for 7 years under a thatched roof and then converted into scantlings.

Notes.—Not seriously cracked, only in a few cases had the heart-shake cracks extended to the circumference and these were neither large nor deep. A system of fine hair cracks had developed, chiefly from the circumference and were considered to be of no importance.

(*i*) (*b*) Logs seasoned for 7 years under a tin roof and then converted into scantlings.

NOTES.—Logs in not quite so good condition as above. Major cracks from the centre had in nearly all cases extended to the circumference. The finer cracks were more numerous and on the whole penetrated deeper into the logs.

(*ii*) Logs seasoned in the open for from 3 years and 5 months to 7 years and then converted into scantlings.

NOTES.—This method of seasoning resulted in severe, compound, heart, radial and cup-shake developing in the timber. Both the size and depth of the major cracks were excessive, while a network of subsidiary cracks had also developed. The state of the timber was, in all instances, far worse than that of timber seasoned under shelter.

(*iii*) Logs immersed in water, then seasoned on land in the open, followed by conversion into scantlings.

NOTES.—At the time the logs were taken out of the water they had hardly cracked at all. Subsequently, while seasoning on land, they developed a certain number of major cracks, and their state was considerably worse than that of timber seasoned on land under shelter. The finer system of cracks did not develop seriously in these logs.

(*iv*) Logs seasoned in open for upwards from 3 years and 3 months to 7 years and felled at different times of the year, followed by conversion into scantlings. These experiments were carried out by seasoning all logs in the open, so that the results are strictly comparative, the only divergent factor being that the trees from which the logs were prepared had been felled at different times of the year.

(*iv*) (*a*) Trees felled in June.

NOTES.—Out of 14 logs inspected, 5 were badly cracked, 6 showed moderate cracking and 3 were in good condition.

(*iv*) (*b*) Trees felled in December.

NOTES.—Out of 12 logs inspected, 6 were badly cracked, 4 moderately so and 2 were in good condition.

(*iii*) *CONCLUSIONS ARRIVED AT FROM THE ABOVE EXPERIMENTS.*—The logs seasoned in the shade under a thatched roof gave the best results, while those seasoned under a tin roof were not greatly inferior.

Seasoning in the open gives distinctly inferior results to seasoning under shelter.

Water seasoning in the log does not improve Sal timber, though it does not materially affect it either way.

Felling the trees at the commencement of the monsoon or in the cold weather does not seem to affect the timber; in any case, it leads to the majority of the logs developing cracks, if seasoned in the open.

In Forest Record, Volume VII, Part I, entitled a "Preliminary Note on the Seasoning of some Indian Timbers, by Natural Methods," page 18, will be found records of other seasoning experiments carried out with Sal timber. The results obtained in those experiments corroborate those recorded above, namely that the best way to season Sal is to store it in the log under shelter.

In the above quoted record, on pages 64 and 65 of the appendices, are given the results arrived at by converting Sal timber when in a green state, followed by seasoning under cover, and it will be seen that this method gives slightly inferior results to seasoning under shelter in the log.

INDIAN FOREST RECORDS

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The Life History of the Toon shoot and fruit borer, *Hypsipyla robusta*, Moore. (Lepidoptera ; Pyralidae ; Phycitinae) with suggestions for its control

BY

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Introduction.

AN enquiry into the life-history and control of the shoot borer of Toon was included in the programme of the Forest Zoologist, passed by the Board of Forestry at its Triennial Meeting in 1913. The subject was investigated during the years 1914-16, but, as it was not considered a major project, progress was frequently interrupted in favour of more important investigations. The enquiry was finally brought to a close in 1916 by the absence of the writer on military duty.

The publication of this record has been delayed for a season in order to include descriptions and an account of the life-histories of the parasites of the borer, but it is now* evident that the war has indefinitely postponed this part of the investigation. An account of the parasites will be published in a subsequent record.

The insectary work was carried out under the direction of the writer by the first Assistant to the Forest Zoologist, Mr. N. C. Chatterjee, B.Sc., who was also in charge of the sack-band collections and who subsequently collated the data. The writer wishes to express his appreciation of the care and discrimination displayed by Mr. Chatterjee in carrying out the experiments entrusted to him.

* Submitted for publication on 2nd January 1919.

PART I.

PREVIOUS HISTORY OF THE PEST.

The earliest mention of this insect, that is traceable, is an enquiry by J. S. G. [amble] in the first volume of the Indian Forester in 1876. It is stated that the insect, " almost yearly, attacks the young shoots of the Toon tree, boring its way along the pith which it seems to live upon, and leaving behind it an unsightly looking mass of transparent gummy exudation. It attacks trees both in plantations and in the forests, and prefers these about three feet in height and of strong growth. It seems to attack, however, more particularly those trees which grow in cleared land or near roads, while others growing close by in grass or with other trees, have been comparatively unharmed."

In February, 1882, a correspondent in the Tropical Agriculturist records the attacks of a borer in the terminal shoots of young toon planted out in tea estates in Ceylon.

In the same journal in September, 1882, it is reported that young trees of *Cedrela Toona* are attacked by a borer in a similar manner in Queensland.

The Museum of the Forest School, Dehra Dun, before its transfer to the Forest Research Institute contained specimens of this species which were bred in June, 1886, from the fruits of toon.

The species was described by Moore in 1886 [Moore, 1886, p. 365]* from specimens collected in Ceylon.

The Tropical Agriculturist for September, 1888, records attacks by a shoot borer of toon and mahogany in Ceylon. The general opinion at this date with regard to the insect is represented by the following statements : " The little borer which occasionally attacks the toon is not a very serious pest and scarcely affords sufficient reason for cutting down the trees............ The repeated destruction of the terminal twigs causes the continuous production of lateral ones on the branchlets below, so that the character of the tree becomes at last quite altered, and a dense, round, much-branched head results, instead of the usual wide-spreading foliage........."

In January, 1889, specimens of the pest were sent from Ceylon by Mr. E. E. Green to the Indian Museum and the first authentic identification of the insect as a pest of toon was published as *Magiria robusta*, Moore, in the Indian Museum Notes, Vol. I, together with figures of the larva, pupa and moth, [Cotes, 1889]*. Additional records were given of its occurrence as a borer of young mahogany (*Swietenia Mahagoni*)

* For all references to literature in square brackets see Bibliography at the end.

at Alipur, in the Western Duars, at Nilambur, in Madras, and in Ceylon (on the authority of Thwaites).

Indian Museum Notes, Vol. II, p. 16 records that this species was "extremely injurious to the toon trees which line the roads in Dehra Dun" during 1880-91, and notes that nothing is known of its life-history beyond the fact that moths were reared in Ceylon in October from larvae pupating in September. [Cotes, 1891 (*a*) and 1891 (*b*).]

In June 1893 the pest was noticed in large numbers at Roorkee, U. P. [Cotes, 1896, p. 66], so that "every toon tree in the station was covered with matted silk from base to top."

The Indian Forester for September, 1899, [Coventry, 1899, pp. 366-370] contains an account of the life-history of the pest by B. O. Coventry as observed by him at Changa Manga, Lahore Division, Punjab. Mr. Coventry's observations represent the first serious attempt to work out the life-history and habits of the pest. He was the first to show that the borer of toon fruits and the borer of young shoots are the same species, but his interpretation of the seasonal history as a cycle of two generations we now know to be incorrect, (*vide* p. 62).

In 1902, E. P. Stebbing published an account of the life-history of the pest [Stebbing, 1902, pp. 312-317], which beyond querying Coventry's observations added nothing to the existing information on the species.

A record of the occurrence of the pest at Champaran, Bengal, in June and August, 1901, is given in Indian Museum Notes V, [Stebbing, 1903].

A short account of *Hypsipyla robusta* is given on p. 136 of the Manual of Forest Zoology [Stebbing, 1908], but it is erroneously assumed that the seasonal history consists of two generations.

In Indian Insect Life [Lefroy, 1909, p. 514], fig. 331, p. 495 which illustrates the larva and moth of *Hypsipyla robusta* is assigned in error to *Cossus cadambœ.*

It will be observed that since 1899 nothing has been added to our knowledge of the life-history of this pest in India, apart from the results of research carried out at this Institute in 1914-16.

The Report of the Resolutions, Proceedings, and Debates of the Interstate Conference on Forestry held at Perth, Western Australia, in November 1917, includes (pp. 94-95) an account of the enemies of the Red Cedar, *Cedrela australis.* (See also Queensland Forestry Bulletin, No. 3, pt. 1, pp. 14-15). It is stated that "the formation of Cedar plantations on a large scale cannot be justified until sufficient time has elapsed to determine to what extent the young saplings will outgrow the damage, or until satisfactory remedial measures have been found." It is also observed that plantations of a closely allied cedar are similarly attacked in Trinidad.

In reply to a request from the Director of Forests, Brisbane, Australia, in 1917, the writer supplied an account of the life-history of *Hypsipyla robusta* with the methods of control which had been found successful in the Dehra Dun district. This information was published in the Australian Forestry Journal for January 1918, Vol. I, No. 1, p. 33.

SYSTEMATIC POSITION.

Hypsipyla is classed in the subfamily *Phycitinæ* of the family Pyralidae, order Lepidoptera, and is placed by Hampson between the genera *Myelois* and *Phycita*.

The subfamily *Phycitinæ* contains numerous genera which are of economic importance in connection with agricultural crops, fruit and forest trees in various parts of the world ; the species exhibit a great diversity of feeding habits. Species of *Ephestia* feed in stored rice and wheat flour; *Heterographis* bores in fruits ; some species of *Euzophera* bore in seeds and fruits, and others are bark-borers ; species of *Phycita* are seed and shoot-borers, leaf-rollers, and general rubbish feeders ; *Dioryctria* includes shoot and bark-borers, and *Etiella* pod-borers.

Two other species of *Hypsipyla* are recorded from India, but their habits are unknown.

SYNONOMY OF THE SPECIES.

HYPSIPYLA ROBUSTA, Moore, (1886)

Magiria robusta . . Moore, (1886) Lep. Ceyl., III, p. 365, pl. 184 fig. 4, 4*a*.
Rag., Mon. Phyc., p. 139, pl. VI, fig. 12.
Cotes and Swinhoe, (1889) Cat. Moths. Ind., No. 4598.

Hypsipyla pagodella . Rag. (1888) Nouv. Gen. et Especes de Phyc., p. 10.
Cotes and Swinhoe, (1889), Cat. Moths Ind., No. 4566.

Hypsipyla robusta . . Hampson (1896), Faun. Brit. Ind., Moths, IV, p. 89, No. 4384.
Kenrick (1907), Proc. Zool. Soc., p. 69.

The references quoted above do not include those dealing with the biology and economic importance of the species ; for the latter see Bibliography at the end.

DISTRIBUTION.

As noted elsewhere, (p. 18) the moth is rarely met with in the field in spite of its abundance, and it is therefore not surprising to find that specimens, other than bred individuals, are rare in collections in India. I am indebted to the following gentlemen for records of specimens of *Hypsipyla robusta* in their collections :—The Director of the Zoological Survey, Calcutta, the Imperial Entomologist, Pusa, Mr. O. Lindgren, Nagri Spur, Darjeeling, and the Government Entomologist, Ceylon.

INDIA . . Peshawar, Dharmsala, Kangra, Simla, Lahore, Changa Manga, Punjab; Dehra Dun, Siwaliks, Roorkee, Kathgodam, Lucknow, U. P.; Alipur-Duars, Buxa, Darjeeling, Kurseong, Champaran, Bengal; Sikkim; Nilambar, Madras;

BURMA . Myitkyina, Katha, Bhamo, Maymyo, N. Shan States S. Andamans.

CEYLON; PERAK; BRITISH NEW GUINEA.

AUSTRALIA . Queensland; N. S. Wales.

FOOD-PLANTS.

Meliaceæ.

Cedrela Toona, Roxb. in India, Burma, Ceylon.

Cedrela australis, F. von Muell in Queensland and N. S. Wales.

Cedrela multijuga, Kurz. in Burma *

Swietenia Mahagoni, Linn. in India and Ceylon.

Swietenia macrophylla, King, in Ceylon.

Chickrassia tabularis, Adr. Juss. at Dehra Dun.

Soymida febrifuga, Adr. Juss. at Dehra Dun.

Rosaceae.

Rosa sp., (Hedge-rose).†

Rutaceæ.

Citrus medica, Linn. (Lime) in Perak.

* It is possible that this record of *taungdama* as a food-plant should be referred to *C. Toona*.

† N. C. C. teste.

PART II.

DESCRIPTIONS OF THE STAGES OF THE INSECT.

The insect is very easily recognised in all its stages from the figures given on Plate IV and general descriptions are hardly necessary. The following technical descriptions and illustrations are given as none have previously been published.*

1. The Adult.

TECHNICAL DESCRIPTION (after Hampson, 1896, p. 89).

Generic characters. "Palpi upturned and slender, the 2nd joint reaching above vertex of head, the 3rd long and acuminate, maxillary palpi filiform ; antennæ of female somewhat thickened and ciliated ; mid and hind tibiæ with tufts of spinous hair on outer side at base and extremity. Fore wing narrow ; vein 2 from near angle of cell ; 4, 5 approximated for a short distance, 10, 11 free. Hind wing with the cell half length of wing ; vein 2 from well before angle ; 3 from angle ; 4, 5 shortly stalked ; 6, 7 from upper angle, anastomosing with 8."

Specific characters. "Pale rufous brown irrorated with black and grey ; Fore wing with the costal half strongly suffused with grey ; the veins all streaked with black ; some olive yellow on base of costa and median nervure on extremity of median nervure and discocellulars ; traces of a dark sinuous medial line, with a dark patch beyond it on the inner margin and of a very highly dentate oblique dark postmedial line bent outwards between veins 5 and 2. [In the Dehra Dun specimens the medial and postmedial lines are usually well marked]. Hind wing semihyaline, white ; the costal area suffused with fuscous ; the base of cilia pale rufous"

Wing expanse. Male, 26-32 mm. Female, 28-42 mm.

Relative proportion of the sexes. In a brood of 473 individuals of the 5th generation bred in 1916, Dehra Dun, the proportion is :—*Males* 77·4 per cent., *Females* 22·6 per cent. In two lots of material received from Changa Manga, Punjab, the proportion is :—*Males* 75 per cent., *Females* 25 per cent.

2. The Egg.

Colour white, opaline, translucent. *Form* oval in horizontal section, bi-concavo-convex in vertical section ; dorsal and ventral surfaces

* I am indebted to my first assistant, Mr. N.C. Chatterjee, B.Sc., and to my senior Artist, B Jung Bahadur Singh for careful independent checks of the technical descriptions. C. F C. B.

slightly concave, lateral surface convex, the anterior area being more rounded than the posterior area ; *Chorion* very finely reticulated.

Length 0·9 mm., breadth 0·75 mm., height (at anterior end) 0·5 mm. Emergence by a circular cut at the anterior end.

3. The Larva.

[Plate I, figs. 1-3, Plate II, figs. 1-6.]

GENERAL DESCRIPTION. For the general appearance of the larva see Plate IV, figs 2-5 and Plate I, figs. 1-3. Its colour varies from pale straw through brown, pink, green to blue [see sequence of colour changes detailed on pp. 28, 29]. In all stages a series of black spots (the setiferous tubercles) is prominent in 5 longitudinal rows on each side of the body ; the spots of the first and third rows are larger than the others ; the small brown spots between the third and fourth rows are the spiracles.

TECHNICAL DESCRIPTION. Described from a long series of individuals of all generations, Dehra Dun.* The first three instars are not readily separable except by size and slight differences in the arrangement of tuberclets.

* Notation of setiferous tubercles. T I=anterior trapezoidals ; T II=posterior trapezoidals ; T III=supraspiraculars ; T IV and T V=subspiraculars ; T VI=laterals : T VII=marginals.

The teriminology used is that of Dyar, 1895 and Forbes, 1910; comparison with that of Fracker, 1915 may be made from the subjoined list of synonyms.

PROTHORAX.			MESO-AND METATHORAX.			ABDOMEN		
Author		Fracker	Author		Fracker	Author		Fracker
I a	=	alpha .	I a	=	alpha .	I	=	alpha.
I b	=	gamma .	I b	=	beta .			
I c	=	epsilon .						
II a	=	beta . .	II a	=	epsilon .	II	=	beta.
II b	=	delta .	II b	=	rho .			
II c	=	rho . .	III	=	theta .	III	=	rho.
IV+V	=	kappa group	IV	=	kappa .	IV	=	kappa.
			V	=	eta .	V	=	eta.
VI	=	pi group .	VI	=	pi . .	VI	=	mu.
VII	=	„ „ .	VII	=	pi group .	VII	=	pi group.

THE FIRST INSTAR.

Length 1·6 mm.$=\frac{1}{16}''$ when newly hatched, to 4 mm.$=\frac{5}{32}''$.

Colour stramineus to pale brown. Head dark brown, prothoracic plate and tubercular shields dark brown. Appearance more hairy than older larvae.

Arrangement of Setæ. Differs from the arrangement in the mature, 4th stage larva only with regard to minor tuberclets. Prothorax with IIc., sometimes absent; tuberclets posterior to the pronotal plate, and on subsegment 4, absent.

First abdominal segment with a tuberclet antro lateral to T I, present or absent; supraspiracular tuberclet below T III absent.

THE SECOND INSTAR.

Length 4 mm.—8 mm.$=\frac{5}{32}''$ —$\frac{5}{16}''$.

Colour pale brown to brown.

Arrangement of Setæ and tuberclets similar to the first instar.

THE THIRD INSTAR.

Length 8 mm.—16 mm.$=\frac{5}{16}''$ —$\frac{5}{8}''$

Colour pale brown to reddish brown.

Arrangement of Setæ as in fourth instar.

THE FOURTH INSTAR.

Length 19·1 mm.—28·6 mm.$=\frac{3}{4}''$ —$1\frac{1}{8}''$.

Colour reddish brown to blue. Head dark brown, sometimes with chestnut tinge; pronotal plate and tubercular shields very dark brown or black; shields on the 9th and 10th abdominal segments yellowish brown.

Form [See Plate I, figs. 1, 2] subfusiform, shining, without secondary hair. Legs normal, dark-brown, pubescent. Prolegs with crotchets 40-46, triordinal [see Plate II, fig. 5] arranged in an oval; anal proleg crotchets 24-30 triordinal, semioval [see Plate II, fig. 2]; the crotchets of the 3rd series are very minute, equal in number to and alternate with the long and short crotchets. Spiracles orange or light brown, subcircular, margins slightly elevated.

Head (the arrangement of setæ has not been homologised, but see Text fig. I). Ocelli 6, I, II, V and VI forming a rectangle, III and IV on the line II, V. Antennæ (fig. 1) 4 jointed, 2nd longer than the remaining joints united, 4th very minute; two long acute papillæ, one short hair and one very long bristle on distal edge of 2nd joint; one long pointed papilla and one long seta on 3rd joint; 4th joint

Description of Plate I.

Larva of Hypsipyla robusta, *Moore.*

Fig. 1. Fourth stage larva, $\times 4$, lateral view.

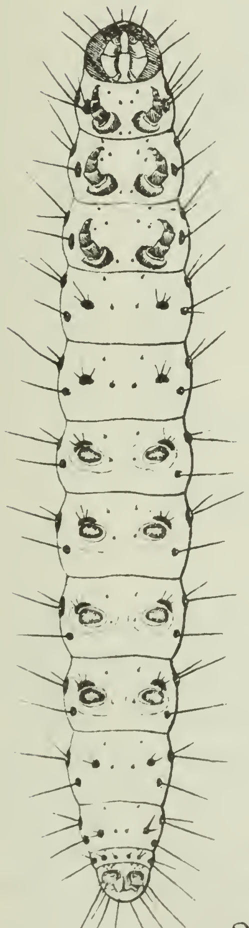
Fig. 2. Fourth stage larva, $\times 4$, ventral view.

Fig. 3. Diagramatic representation of the arrangement of setiferous tubercles on the body; Ti, first thoracic segment; Tii—iii, second and third thoracic segments; A iii, third abdominal segment; A viii, eighth abdominal segment; A ix, ninth abdominal segment; A x, tenth abdominal segment.

I, a, b, c, = anterior trapezoidals.
II, a, b, c, = posterior trapezoidals.
III, = supraspiraculars.
IV, V = subspiraculars.
VI = laterals.
VII = marginals.

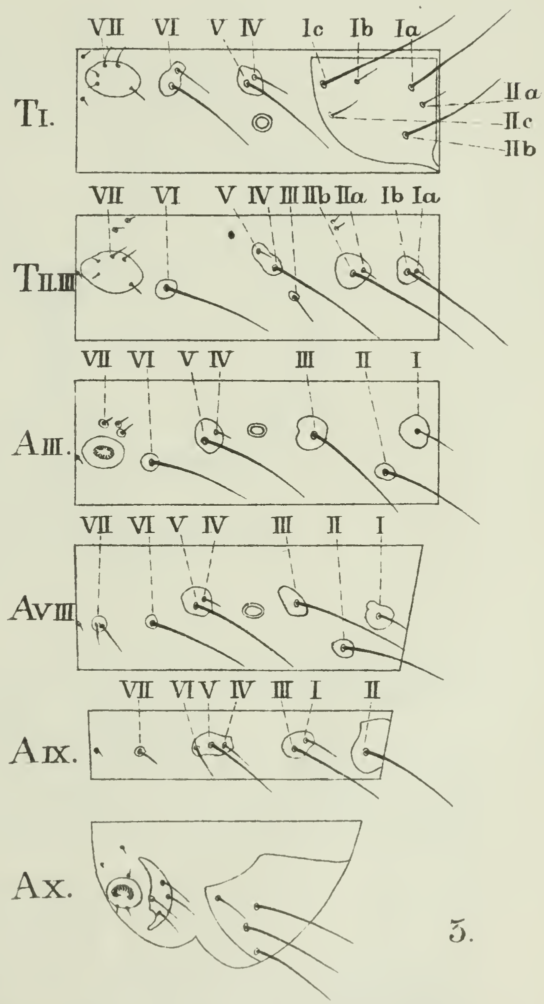
×4.

1.



×4.

2.



3.

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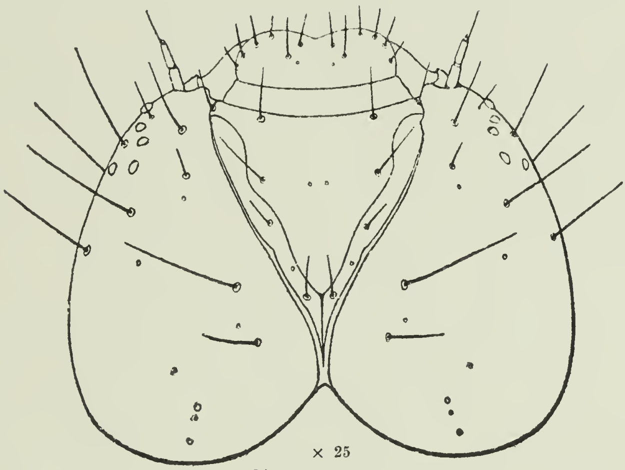
LARVA OF HYPSIPYLA ROBUSTA, MOORE.

[To face page 8.

unarmed. Mandibles (fig. 3) pentadentate, the 3 upper teeth pointed, the 2 lower blunt. Labrum (fig. 6) with median incision, narrow, acute, the six setæ L_1, L_2, L_3 and M_1, M_2, M_3 arranged as in figure; labral punctures mesad of and closely approximate to the bases of setæ M_2. Maxillæ, (fig. 4) Lacinia-galea with 4 long papillæ, 2 laminate, bifid and 2 cylindrical with a minute distal joint, also 3 short processes between the bases of the papillæ; third joint of maxillary palp with numerous short papillæ. Spinneret (fig. 4) relatively short.



Text figure 1.

Arrangement of setæ on head of mature larva of *Hypsipyla robusta,* Moore.

Arrangement of Body Setæ [see Plate I, fig. 3]. The homology of the setæ as presented in the figure is tentative; the relative lengths of the long and short setæ are slightly exaggerated.

THORAX. Pronotal Plate with 6 setæ; Ia, Ib, Ic in a line, submarginal; IIa dorso-caudad and IIb caudad of Ia; IIc caudad of Ic, submarginal; Ib, Ic, IIc equidistant; III absent; IV and V on one shield; VI bisetose.

Mesothorax and metathorax with I, II, IV, and VI in a line and with III caudad of the line; VI unisetose.

ABDOMEN. Segments 1-6 with II ventrocaudad of I; III subspiracular I, III, IV, V and VII in a line with the spiracle; VII trisetose.

Segment 7 similar but with V and VII not in a line, and VII bisetose.

Segment 8 with IV, V slightly ventro-cephalad of the spiracle ; VII variable, unisetose, long or bisetose, long and short. Segment 9, the shield of II on both sides confluent dorsally ; I, III on one shield ; IV, V, VI on one shield ; VII unisetose. Anal shield with 4 setæ.

The larval characters of the genus *Hypsipyla* therefore appear to be :—circle of crotchets complete, triordinal prothorax with IIb twice as far caudad of IIa as IIa is of Ia ; abdominal segment 3 with IV dorso-cephalad of V ; pinacula strongly chitinised ; ocellar arrangement subrectangular.

The following Table 1 gives the measurements (made by Mr. N. C. Chatterjee) of the width of the head in the case of 57 larvæ :—

TABLE 1—*Measurements of the Width of Head of* H. robusta *larvæ.*

FIRST INSTAR.	SECOND INSTAR.	THIRD INSTAR.		FOURTH INSTAR.	
mm.	mm.	mm.	mm.	mm.	mm.
·35	·75	1·0	1·5	2·0	2·25
·4	·75	1·0	1·5	2·0	2·35
·5	·75	1·0	1·5	2·0	2·35
·5	·75	1·25	1·5	2·0	2·5
·5	·75	1·35	1·5	2·0	2·5
	·8	1·35	1·65	2·0	2·5
	·85	1·35	1·65	2·15	2·5
	·9	1·4	1·65	2·15	2·5
	1·0	1·45		2·15	2·5
	1·0			2·15	2·5
	1·25			2·2	2·5
	1·25				

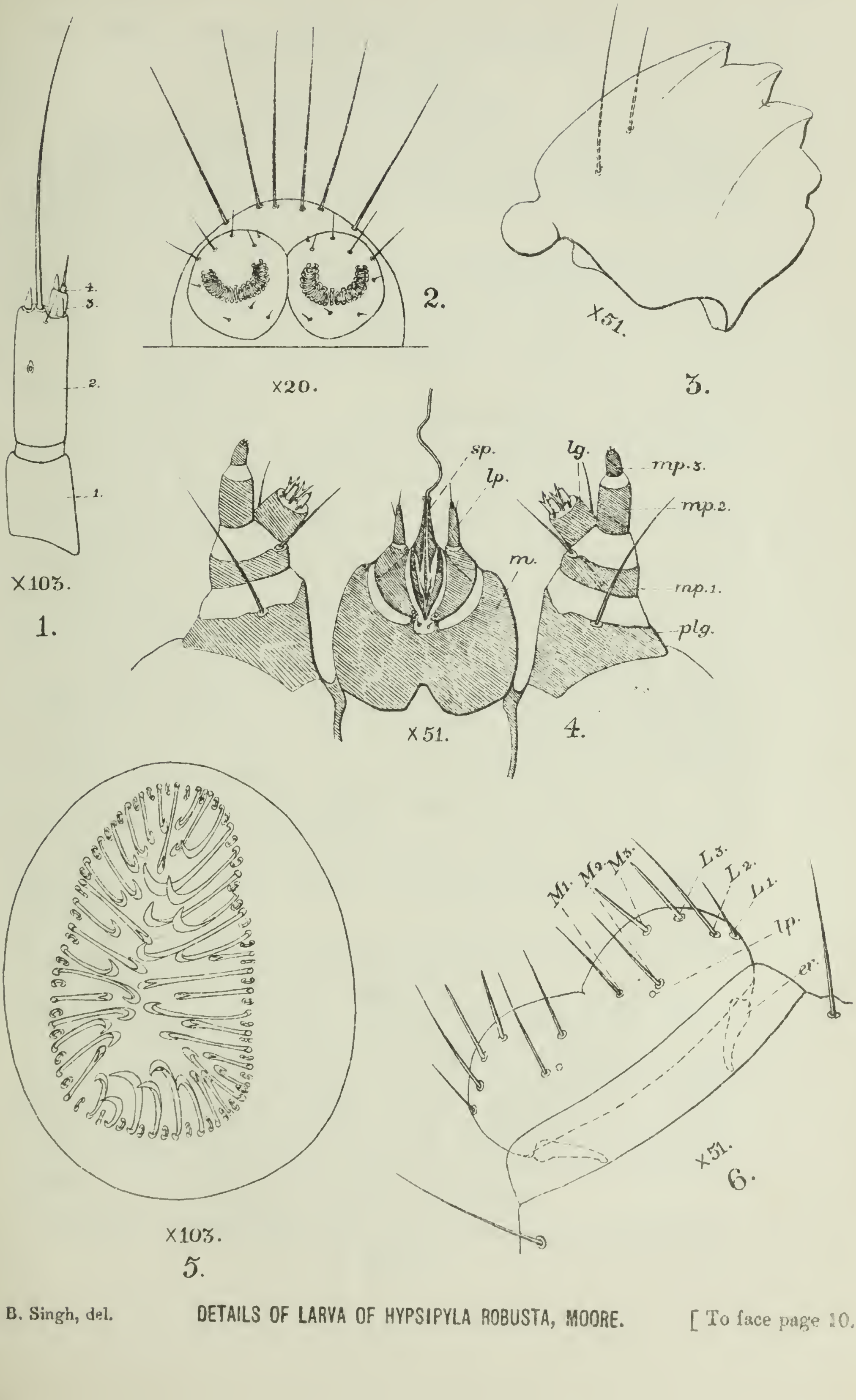
CHANGES IN THE LARVAL COLOUR.

A reference to Table 8 p. 28 will show the colour changes observed to take place in the case of individuals. There is not much variation in colour during the first three stages, which display several shades of brown, but in the fourth stage there is a very perceptible sequence of colour changes. Immediately after the moult a fourth stage larva is of a dark or reddish-brown colour. This gradually fades to a pinkish-brown, changing subsequently to purple or reddish-blue, and finally to a light blue which frequently has a greenish tinge. The light blue colour is characteristic of the mature larva just before pupation and of the mature hibernating larva. The factors influencing the colour changes are unknown, but it may be noted that the fluid escaping from the body of a punctured pupa is invariably bluish-green.

Description of Plate II.

Details of Larva of Hypsipyla robusta, *Moore*.

Fig. 1. Antenna, $\times$ 103. 1, 2, 3, 4 = 1st, 2nd, 3rd and 4th joints.
Fig. 2. Anal Prolegs, ventral view, $\times$ 20.
Fig. 3. Mandible, left, upperside, $\times$ 51.
Fig. 4. Maxillæ and Labrum, underside, $\times$ 51.
lg = lacinia and galea.
mp_1, mp_2, mp_3 = 1st-3rd joints of maxillary palp.
sp = spinneret.
lp = labial palp.
m = mentum.
Fig. 5. Crotchets of Proleg, 6th segment, $\times$ 103.
Fig. 6. Labrum, dorsal view, $\times$ 51.
L_1, L_2, L_3 = 1st-3rd lateral labral setæ.
M_1, M_2, M_3 = 1st-3rd median labral setæ.
lp = labral puncture.
er = epipharyngeal rod.



J. B. Singh, del. DETAILS OF LARVA OF HYPSIPYLA ROBUSTA, MOORE. [To face page 10.

4. The Pupa.

[Plate III, Figs. 1, 2, 3.]

TECHNICAL DESCRIPTION. From numerous specimens collected in the Dehra Dun district. The terminology of Mosher, 1916, " A classification of the lepidoptera based on the characters of the pupa " has been followed throughout.

Colour. The freshly formed pupa is light bluish-green in colour, the subsequent changes are passed in the following order :—Greenish-yellow, yellowish-brown, bright reddish-brown to dark chestnut brown ; the full coloration is acquired within 24 hours.

Form. Elongate cylindrical, rounded at cephalic end, bluntly tapering at caudal end.

Median head regions, i.e., vertex+front+clypeus, not separable, no epicranial suture ; fronto-clypeal suture extending mesad for a short distance, (less than the length of the base of the antenna).

Antennæ (a) long extending to level of anterior margin of 4th segment, distal ends separated by maxillæ and 2nd and 3rd legs.

Labrum (l) subcordate, acutely angulate in middle of anterior border.

Pilifers (pf) prominent, rounded, approximate medianly.

Labial palps (lp) concealed by maxillæ except for a small cuneate piece just caudad of the pilifers.

Eye pieces (ep) not easily separable from genæ except in mature pupa ; glazed eyepiece lunate, sculptured eyepiece smaller, triangular.

Maxillæ (mx) broad at base but rapidly narrowing in basal fifth, extending to near middle of 4th abdominal segment but not reaching to caudal margin of wings.

Maxillary palps (mxp) subrectangular, extending as far as the proximo-lateral angle of the maxillæ.

Thorax. Pronotal area, (pt) transverse, anterior border concave, posterior border sinuate, median line carinate, lateral angles obtusely rounded.

Mesonotum, (mst) more than twice as long as pronotum, posterior border deeply concave, median line carinate.

Mesothoracic spiracle (msp)* situate at the caudo-lateral angle of the pronotum, margins elevate, caudal margin transverse.

Legs. First pair (l_1) adjacent to the maxillæ at the proximal end, thence diverging and exposing a narrow fusiform portion of the 3rd pair, later rejoining the maxillæ at about $\frac{1}{2}$ the length of the latter. Second pair, (l_2) exposed for their whole length and extending to the caudal margin of the wings. Third pair, (l_3) concealed except for a portion of the femur and the terminus of the tarsus.

* Mesothoracic according to Mosher, 1916 ; prothoracic according to previous authors.

Wings, (w). The mesothoracic wings extend to beyond the middle, c. $\frac{4}{5}$ths of the fourth abdominal segment, where they are conjointly rounded in a broad arc.

Abdomen, Segments 1-3 fixed. Segments 4, 5, 6 moveable in both sexes. Segments 7-10 fixed. A visible suture but no dorsal furrow between segments 9 and 10. *Spiracles* of abdominal segments 2-7, uniform elliptical, margins elevate ; 8th linear with margins not elevate.

Cremaster represented by 8 small rugosities at the apex of the 10th segment, from which arise 8 cuphooked setæ ; four close together in a row and at either end one slightly postero-lateral and one more distant, antero-lateral.

Proleg scars, (pls), conspicuous on segments 5 and 6 in the form of short pits connected by transverse interrupted striæ.

Setæ, (st), inconspicuous, minute and whitish. On the head three pairs ; on the metathorax one pair, subdorsal ; on the 1-8 abdominal segments 2 pairs, near the cephalic margin, subdorsal, supra-spiracular ; on segments 4-8 one pair subspiracular ; on segments 5-8 one pair subspiracular ; on segment 9 one pair subdorsal, one pair subspiracular ; on segment 10 one pair ventral.

External Genitalia, (go), Female genital aperture a single short median slit extending almost to the cephalic margin of the 8th segment. Male genital aperture larger, the sinus impressed and bordered by elevations.

Anal Opening, (ao), slit-like enclosed by a few longitudinal striations.

Length, (with cremastral hooks), male, 10·5 mm. ; female, 10·75—15·75 mm. ; length of cremastral hooks 0·5 mm.

Variation.—In one case (within the first hundred examined) the 2nd pair of legs extended to the anterior margin, and the antennæ to the middle of the 4th abdominal segment. (Teste N.C.C.)

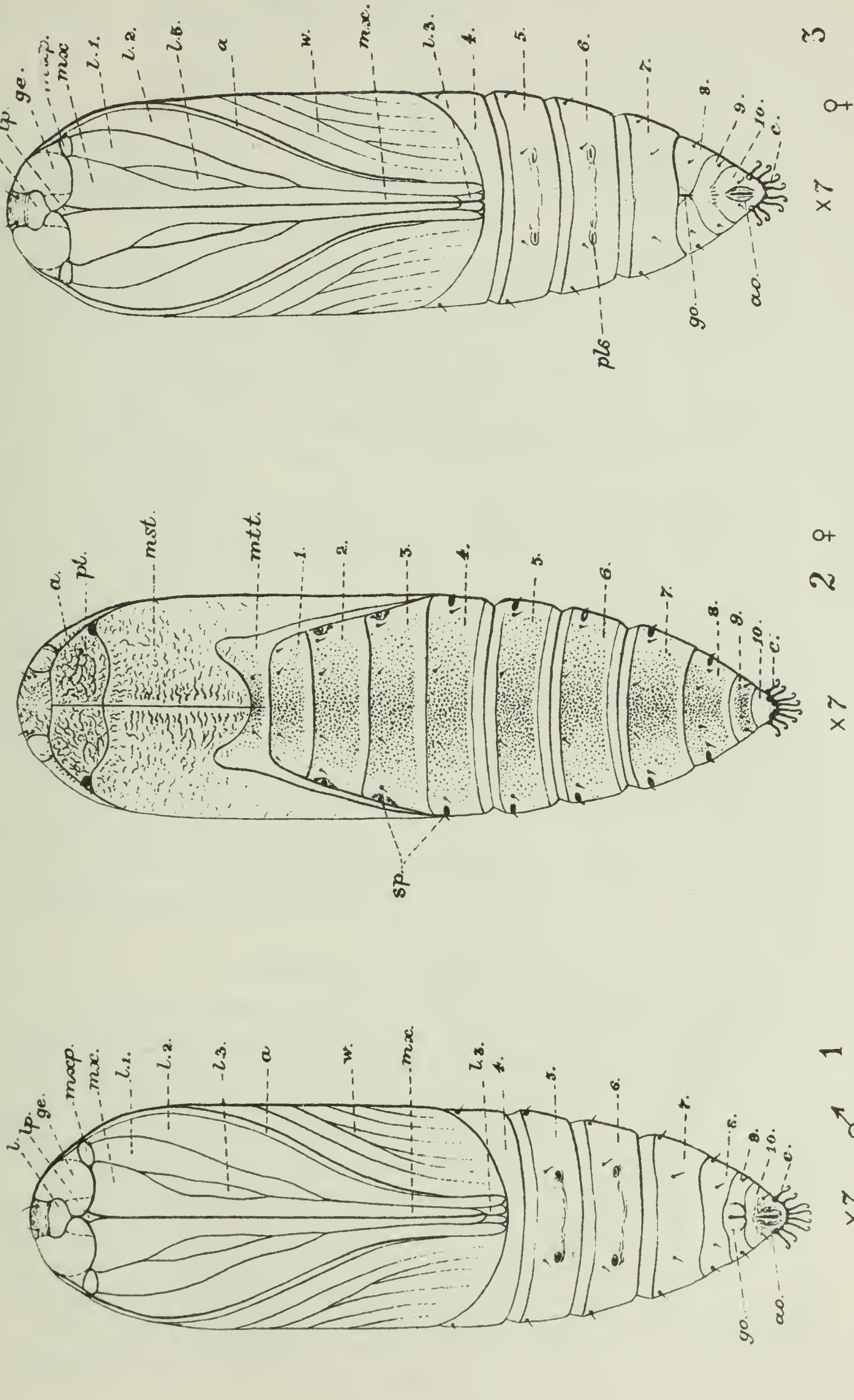
The pupal characters established by Mosher, 1916, p. 75 for the subfamily Phycitinæ include the following :—maxillary palpi present, epicranial suture usually present, dorsal furrow between abdominal segments 9 and 10 (except in the genera *Ephestia* and *Plodia* which, however, possess tubular spiracles on the mesothorax). *Hypsipyla* shows characters which approach those of the Phycitine group containing *Ephestia* and *Plodia*.

Description of Plate III.

Pupa of Hypsipyla robusta, *Moore*.

Fig. 1. Ventral view of ♂ pupa, × 7.
Fig. 2. Dorsal view of ♀ pupa, × 7.
Fig. 3. Ventral view of ♀ pupa, × 7.

a = antenna.
ao = anal opening.
c = cremastral setæ.
ep = eyepiece.
ge = gena.
go = genital opening.
la = labrum.
lp = labial palp.
l_1 = prothoracic leg.
l_2 = mesothoracic leg.
l_3 = metathoracic leg.
msp = mesothoracic spiracle.
mst = mesothorax.
mtt = metathorax.
mx = maxilla.
mxp = maxillary palp.
pf = pilifer.
pls = proleg scars.
pt = prothorax.
sp = abdominal spiracles.
st = setæ.
w = wing.
1—10 = 1st-10th abdominal segments



J. B. Singh, del.

PUPA OF HYPSIPYLA ROBUSTA, MOORE.

[To face page 12.

PART III.

LIFE HISTORY AND HABITS OF THE INSECT.

Definition of terms.

The terminology of this paper conforms as nearly as possible with that used in literature on moth-borers with similar habits, and in particular on the codling-moth. Comparison should be made with bulletins of the U. S. A. Department of Agriculture. (*e.g.*, Brooks and Blakeslee, 1915, Bull. 189; Siegler and Simanton, 1915, Bull. 252, etc.).

The term *brood* is used to designate the insect in any one of its four stages in any generation. Thus, a first brood larva refers to a larva of the first generation.

The term *generation* includes all stages of the life-cycle, and is considered to commence with the egg stage and terminate with the moth or imaginal stage.

The *life-cycle* is a period extending from the deposition of the eggs of one generation to the emergence of the adult of that generation.

The complete life-cycle of a generation includes the time from the deposition of the egg of that generation to the deposition of the egg of the next.

The *limits* of a generation are considered to be defined by the dates of deposition of the first egg of that generation and the emergence of the last moth of that generation.

The *seasonal history* of the insect comprises the several histories of all generations in one annual cycle.

Number of Generations.

The seasonal history of the toon fruit and shoot borer, *Hypsipyla robusta*, during a period of one year, normally consists of five generations. The succession of the generations is here summarized, but in the subsequent tables and records, Part IV, are given details of the periods and limits of the stages, broods, swarming periods, etc.

The eggs of the first generation are laid early in March when the toon is in flower and the first brood larvæ feed on the flowers until the first week in April. The whole development is relatively rapid. The life-cycle from egg to moth is completed ordinarily in 24-29 days, and the whole generation is confined within a period of 8 or 9 weeks.

The second generation possesses similarly a short life-cycle. The earliest individuals of the second-brood larvæ emerge early in April, at the time when the fruits are set and the capsules already well advanced and the entire larval development is passed in the growing fruits ; late individuals may be found up till the beginning of June. The life-cycle from egg to moth is completed in 3 to 4 weeks, and the whole generation extends over a period of 9 to 10 weeks.

The larvæ of *the third generation* feed entirely on the new shoots, which are put out during the hot weather. Third-brood larvæ occur from early in May until the middle of July. The change in the food-material is accompanied by a relative lengthening of the life-cycle, which from egg to moth occupies 9 to 11 weeks, with fourth brood larvæ prevalent from the end of July until the second week in September.

The fifth or overwintering generation is the longest and the larva passes most of its time in a hibernaculum inside the shoot. The first individuals of this generation appear early in October, when the autumn flush of new shoots occurs, and the majority have bored into shoots before the winter leaf-shedding commences. The development of the insect in its earlier stages is normal, and is followed by a hibernating period of 14 to 16 weeks. The life-cycle from egg to moth is complete in 21 to 24 weeks and the whole generation occupies a period of 28 to 31 weeks.

Larval activities, and mode of feeding.

1. The flower and fruit generations.

First generation.

The larvæ of the first generation, hatching from eggs laid on the flowering shoots of the toon, feed gregariously on all parts of the paniculate inflorescence. While feeding, the larvæ bind together individual flowers or adjacent groups of flowers by means of a loose network of silk threads, in which portions of the flowers petals, ovaries, pedicels, etc., together with fragments of larval excreta become entangled [Plate IV, fig. 9]. A panicle in which a colony of larvæ is feeding, therefore, presents a characteristic appearance, and should the whole inflorescence be covered with a silk-web, it remains as a ragged mass of shrivelled floral fragments for some time after the dispersal of the larvæ. Although the network of silk threads provides ample protection to the growing caterpillars, yet each individual before moulting prepares a cell of more densely woven silk in which to shed its skin. An abandoned panicle contains numerous moult-cells varying in dimensions with the size of the larvæ that constructed them.

Second generation.

By the time the second brood larvæ are abundant, the flowers of the toon are falling and the young fruit capsules are developing.* The larvæ feed on the fruits, selecting the youngest and softest while in the first instar and feeding mainly on the epidermis. Older larvæ attack more advanced fruits and feed mainly within them, eating the seeds and the soft white tissue of the dissepiments and the axis, and avoiding the harder epidermis of the valves. Larvæ of the first instar are rarely able to penetrate the outer epidermis of the fruit capsule, if it is at all suberised, and in the absence of softer green fruits are unable to feed. During the feeding period the fruits are bound together in groups of 3 to 5 with silk-web, in which are entangled brown desiccated fragments of fruits and pellets of excrement [Plate IV, fig. 10]. A larva lives inside one fruit until the edible portions are consumed, on which it emerges, and bores a hole into the fruit immediately alongside, fastening the new fruit to the one previously occupied with silk threads. While feeding within a fruit the entrance hole is plugged by a compact mass of excreta and ejected fragments of pith [fig. 11].

Dispersal and pre-pupal movements.

Larvæ of the first and second generations, when full grown, lower themselves from the crown of the tree, in the early morning, by means of silk threads. Many, checked in their descent by the lower branches, abandon the thread and crawl down the trunk. Those that reach the ground direct, invariably again crawl up the trunk of the tree in search of crevices or recesses in the flakes of bark on the bole and larger branches suitable for pupation, and there is a constant movement of larvæ in all directions on the trunk and adjoining undergrowth. During the course of their wandering silk is continuously spun in the paths of individual larvæ, and in the case of badly infested trees, especially those with smooth bark, the quantity of silk spun is sufficient to form a connected sheet of silk-web round the whole bole of the tree, from the crown branches to the ground.

If the food supply on any branch of a tree is exhausted before the brood is full-grown, the larvæ drop down and migrate to other trees or other parts of the same tree. The majority of larvæ observed acting

* There is naturally considerable variation locally and among individual trees in the dates of flowering and the ripening of fruits. The majority of trees fruit in May, but it is not uncommon to find young fruits and ripe fruits which have shed their seeds, at one and the same time. This does not influence the habits of the broods as much as would be expected; an early moth of the second generation is more likely to lay eggs on the buds or leaves of early shoots than on late but still attractive fruits.

under such conditions have been found to be in the third stage. During the season on approaching a badly infested tree, one is frequently checked by the silk threads left by descending larvæ, while a vehicle travelling along a road bordered by toon trees collects large numbers of 3rd and 4th stage caterpillars and silk in sufficient amount to constitute a nuisance. The rôle played by vehicles and pedestrians in the dispersal of the pest along the main thoroughfares is obvious.

As in the case of many lepidoptera, the caterpillar is able to climb up its silk-thread by the following procedure. The larva extending its head upwards grips the thread between the mandibles, and hauling on it lifts the body until the thread can be looped over one of the third pair of legs. The mandibles take a fresh grip and the body is again lifted up until the thread is caught over the third leg on the opposite side. This process is carried out alternately on either leg until a skein is formed which impedes further progress ; this is removed at intervals by the prolegs of the anal segment.

Pupation. The first and second brood larvæ pupate almost invariably under flakes of bark on the trunk and main branches of the tree on which they have fed. The cocoon is described later (*vide* p. 17). Cocoons are frequently closely packed in masses two and three layers deep amounting to more than one thousand to the square foot. Such overcrowding makes it impossible for the lowest and earliest pupated moths to emerge, and a large proportion never leaves the cocoons. Given suitable accidental localities for pupation near their host tree, *e.g.*, houses, fences, walls, stacks of fuel or timber, miscellaneous rubbish, etc., larvæ spin up in such places, but they rarely pupate in natural cover such as undergrowth, dead leaves, stones, etc.

2. THE SHOOT GENERATIONS.

Third, fourth and fifth generations.

Larvæ of the third, fourth and fifth generations feed only in the shoots of the current year. Saplings and young trees, which owing to the absence of flowers are not attacked by the first two generations of the pest are subject to attack by the three later generations of the year. Owing also to the greater abundance of new growth in the younger trees, the highest intensity of attack is shifted from the old to the young trees.

Eggs are laid as a rule on the new unexpanded leaves [*vide* Plate IV, fig. 1] ; the larva on hatching descends to the stouter portions of the growing shoot and feeds by removing the epidermis in irregular patches, at the same time testing the shoot for suitable spots to bore into the interior. If too vigorous tissue is selected as the site of entry the attack is unsuccessful, and a flow of sap or gum results, which may entrap and drown the larva. Constant tapping of sap apparently weakens the shoot, and the larva eventually gains entrance. Once established within the shoot, the larva excavates a central gallery in the pith, which is increased gradually during the feeding period until it may attain a length of two feet. The larva usually remains in one shoot during the course of its life, but under certain conditions, as for example, in stunted rapidly killed shoots, the larva of later instars abandons its original gallery, and attacks a second shoot, boring in at a spot where the epidermis is more suberised or at the axil of a leaf or smaller twig. A gummy mass of frass and excreta bound up with silk webbing marks the site of the entrance hole. [*vide* Plate IV, fig. 13.]

The shoot above the entrance hole dies or shrivels, eventually falling over or breaking off at the point of weakness. Below the site of entry, the shoot with its buds and lateral shoots dies and dries up as far downwards as the gallery extends. [*vide* Plate IV, fig. 15.]

Within the shoot the larva constructs at intervals partitions of silk [*vide* Plate IV, fig. 14], which act as a safeguard against the entrance of predaceous insects and parasites, and also keep out rain-water.

The combined work of the third and fourth broods kills off the shoot growth of the year, while the fifth brood larvæ are in a position to attack, any new shoots that may be put out by the tree after the rains have ceased. The aggregate effect is a complete cessation of height-growth and the production of bunches of stunted witches'-broom-like shoots. In certain cases, especially among the fifth brood larvæ, the gallery may be continued down into stems of the previous years' growth. Such stems, although hollowed out do not as a rule die back.

After the emergence of the moths the hollow portions of stems are occupied by various insects, *e.g.*, many species of ants (*Formicidæ*), bees (*Apidæ*) and wasps (*Sphegidæ*), which delay the occlusion of injured tissues.

Pupation. The third, fourth and fifth brood larvæ pupate towards the base of the hollowed shoot after constructing at least one partition of silk in addition to the cocoon. Fifth brood larvæ which hibernate without pupation invariably construct silken hibernacula.

PUPAL AND IMAGINAL HABITS.

1. *Habits of the Pupa.*

The cocoon. The location of the pupa has already been alluded to. In the first and second generations, pupation takes place in concealment under bark flakes or in accidental shelters ; in the third, fourth, and fifth generations, pupation normally takes place in the hollowed shoots. The larva constructs a loose cocoon of white silk strands firmly attached to the bark or sides of the mined shoot. The cocoon is sufficiently open in texture to reveal the outline of the pupating larva or pupa within. The empty pupal shell remains within the cocoon when the moth emerges.

Dehiscence and Emergence. The process of pupal dehiscence commences by a separation at the suture between the antennal scape and the dorsal head piece. The split extends until it reaches the line of the median dorsal suture of the thorax ; a palpitation of the thorax assists in the opening of the median suture, and reveals the dorsum and a portion of the wings. The first forward thrust of the moth within the pupal case tears away the dorsal head piece from the anterior margin of the prothorax, and with the second movement the whole front (dorsal and ventral head pieces) is pushed forward by the emerging moth of which the eyes, head, and antennal bases become visible. Two or three additional movements given mainly by the legs serve to extrude the whole body from the pupal case. The time taken from the first splitting to the emergence of the moth is about 30 seconds.

After about 20 seconds the wings begin to distend appreciably and are fully expanded at the end of another 45 seconds. The moth then lowers the upraised wings on the back and crawls forward a short distance to rest. The total period elapsing from the commencement of dehiscence to the completion of wing development is about 2 minutes. (N. C. C. teste).

2. *Imaginal habits.*

The imago of the toon fruit and shoot borer is an inconspicuous moth of retiring habits and is rarely met with in the field. Throughout the work in the toon avenues of the Dehra Dun district no moths were captured during the day, except a few recently emerged individuals found on the shoots from which they had escaped, and none was taken at light* or in traps. Moths liberated in the large out-door cages attached to the insectary, however, made little attempts to conceal themselves, but came to rest openly on the wire gauze walls of the cage. The resting attitude of the moth is shown in fig. 16, Plate IV. They were not observed to feed although supplied with sweetened liquids and toon flowers, or to display any activity except occasional vibration of the wings in the early morning and late evening.

* Mr. O. Lindgren, Turzum, Nagri Spur, Darjeeling informs me that he has taken this moth at light in May, June and the early part of July.

Description of Plate IV.

The Seasonal History of the Toon Shoot and Fruit Borer.

Fig. 1. Young leafy shoot of *Cedrela Toona* with egg of *Hypsipyla robusta.*

Fig. 2. First stage larva.

Fig. 3. Second stage larva.

Fig. 4. Third stage larva.

Fig. 5. Fourth stage larva.

Fig. 6. Pupa.

Fig. 7. Moth, ♂

Fig. 8. Moth, ♀

Fig. 9. Inflorescence of *Cedrela Toona* with *robusta* larvæ feeding on flowers showing webbed mass of flower fragments and excreta.

Fig. 10. Panicle of immature fruits of *Cedrela Toona* with larvæ feeding on and in the fruits, showing frass and emergence holes,(half natural size).

Fig. 11. Fruit opened out to show larva within.

Fig. 12. Current year's shoot of *Cedrela Toona* attacked near summit by a *robusta* larva, showing

Fig. 13. the excrement and particles of pith ejected.

Fig. 14. Current year's shoot towards end of the growing season opened out to show larva within and silk-work spun previously to hibernation.

Fig 15. Last year's shoot, dead and broken, as a result of attack by *Hypsipyla obusta.*

Fig. 16. Moth, showing resting attitude.

J. B. Singh, pinx.

SEASONAL HISTORY OF HYPSIPYLA ROBUSTA, Moore.

Pairing and oviposition. During the life-history studies from 1913 to 1917, numerous attempts were made to pair the moths in rearing cages and obtain eggs. All obvious conditions were tried, *e.g.*, cages of wire, muslin, glass, and pottery with few and with numerous individuals, in light, shade and darkness, with flowers, fruits and shoots, and finally with a growing toon tree in a large outdoor cage. Only in the latter case was success obtained. Moths lived in captivity up to ten days.

Number of eggs laid. To obtain an indication of the number of eggs laid, a dozen females were dissected and the ova counted. The maximum per individual was 624 and the minimum 228. The average is 472.

Incubation period. In the field eggs were found laid on flowers, on young fruits, and on developing leaves and leaf buds. The eggs are laid singly, firmly attached by a fluid secretion from the cement gland of the female moth. The eggs hatch in 4 to 5 days.

PART IV.

SEASONAL HISTORY STUDIES.

1. Seasonal History in Dehra Dun, U. P.

1. THE FIRST GENERATION.

A generation of the insect as we have defined it on p. 13 is considered to commence with the egg stage and terminate with the moth stage; but in order to obtain a starting-off point for a consideration of the first generation, it is necessary to record initially the emergence period of the moths of the fifth or overwintering generation, since these moths produce the eggs of the first generation.

The spring brood of moths (5th Generation).

Material for emergence records of the first, spring, brood of moths (fifth generation) was collected in the form of shoots of toon containing larvæ from various localities in the neighbourhood of Dehra Dun. The infested shoots were kept under different conditions of temperature and humidity,to determine the influence of these factors on the length of the pupal period and the emergence of the moth; the experiments are dealt with in the section of the fifth generation larvæ. The table below shows the comparative emergence period of fifth generation moths in 1914-16.

TABLE 2.—*Dates of emergence of moths of the spring brood (Fifth Generation) in 1914, 1915 and 1916.*

Date of Emergence.	1914. Number of moths.	1915. Number of moths.	1916. Number of moths.	Total number of moths.
February—				
18th	..	..	2	2
22nd	..	..	1	1
23rd	..	..	..	..
24th	..	..	..	..
25th	..	..	1	1
26th	..	..	..	..
27th	1	..	..	1
28th	..	..	..	..
29th	..	..	1	1

Date of Emergence.	1914. Number of moths.	1915. Number of moths.	1916. Number of moths.	Total number of moths.
March—				
1st	..	..	1	1
2nd	..	..	..	..
3rd	..	..	..	..
4th	..	..	4	4
5th	..	..	..	..
6th	..	..	6	6
7th	1	..	9	10
8th	..	..	5	5
9th	1	..	9	10
10th	..	..	23	23
11th	..	..	28	28
12th	1	..	28	29
13th	..	..	26	26
14th	..	..	27	27
15th	1	..	82	83
16th	..	..	62	62
17th	2	1	56	59
18th	..	2	27	29
19th	3	..	21	24
20th	3	4	17	24
21st	4	4	8	16
22nd	2	5	4	11
23rd	..	6	1	7
24th	2	4	12	18
25th	4	4	5	13
26th	..	3	3	6
27th	2	5	1	8
28th	..	4	1	5
29th	..	5	..	5
30th	2	3	..	5
31st	..	3	..	3
April—				
1st	..	..	..	..
2nd	..	2	1	3
3rd	..	..	..	..
4th	..	3	..	3
5th	..	..	..	..
6th	1	2	..	3
7th	..	..	1	1
8th	..	1	..	1
9th	..	..	..	..
10th	..	..	..	..
11th	..	1	..	1
12th	..	1	..	1

1915. In January and February, *robusta*-infested toon-shoots were collected for emergence records, but as this year was unusually cold a high percentage of mortality (c. 75%) among the hibernating larvæ was produced, and the number of moths obtained was therefore low. The emergence dates in the 1915 column of Table 2 are based on some 400 shoots, and obviously do not give a correct indication of the normal emergence period of the fifth generation moths ; the earliest pupæ and moths were undoubtedly killed off by frost.

1916. Toon shoots collected during January, February and March 1916 contained mostly mature and pupating larvæ. The emergence records of the moths of this brood are given in the 1916 column of Table 2, and represent a truer indication of the emergence period than do the data obtained in previous years. Plate V shows graphically the curve of emergences of the 1916 generation constructed from the figures in Table 2.

The earliest recorded emergence of moths of the fifth generation is the 18th February and the latest the 12th April, with the optimum period of emergence from the beginning of the 2nd week in March up to the beginning of the 4th week in March.

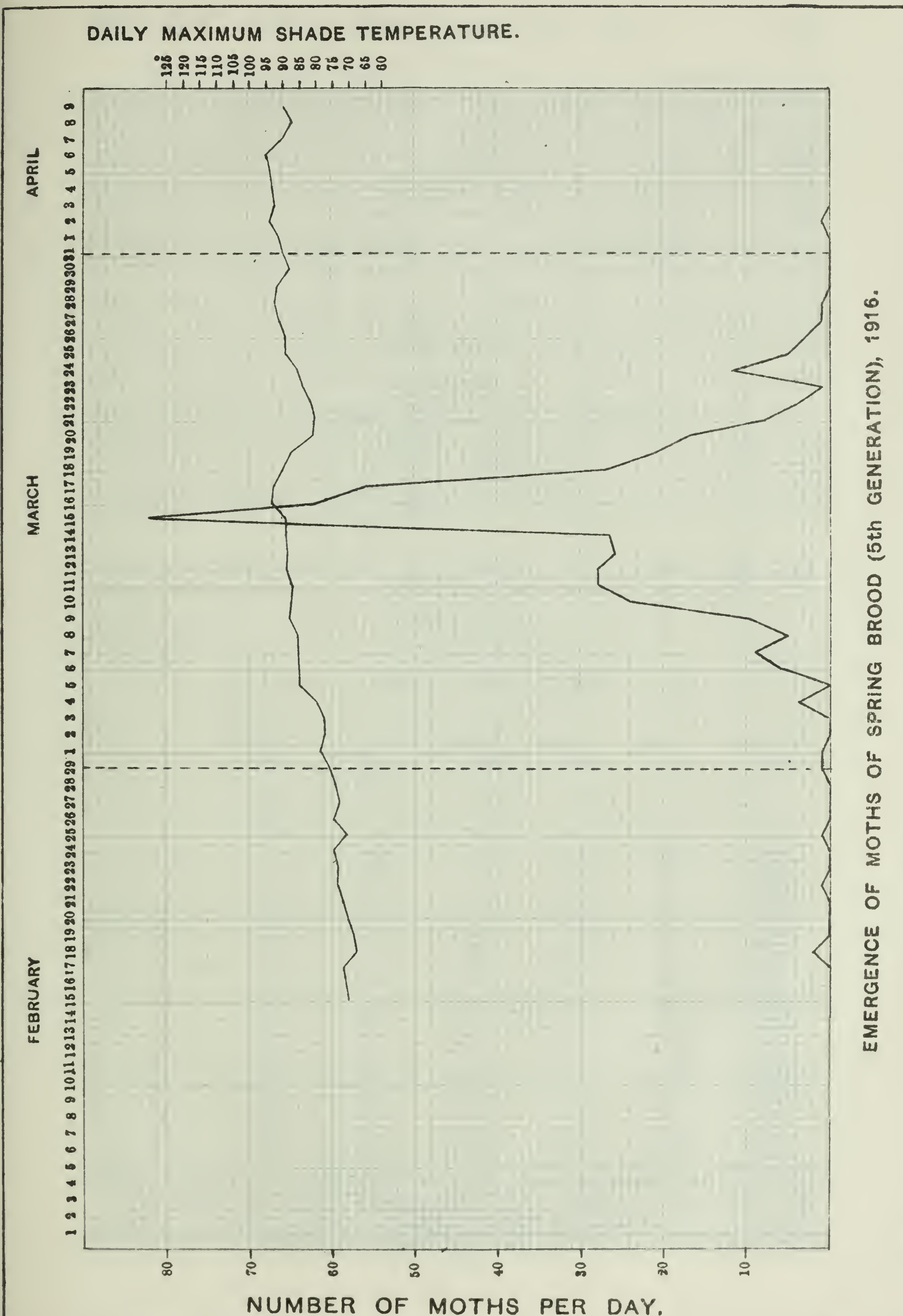
Larvae of the first generation.

1914. As all attempts at mating the moths of the fifth generation failed (*vide* p. 19), no insectary work was possible on the eggs and larvæ of the first generation. During the early spring of 1914 as soon as the toon had commenced to flower, selected trees were periodically examined for signs of larval activity. Shoots and inflorescences were dissected on alternate days in the laboratory, but though the results of attack were frequently detected no larvæ were discovered.

1915. In the following year operations were repeated but with unsatisfactory results. New first stage larvæ were found on April 1st, 1915 in damaged flowers, but all subsequent collections failed to give evidence of the development of the brood.

1916. In 1916 attempts at mating fifth generation moths having again failed, recourse was made to field-work to obtain material of the first generation larvæ. During March and April a very thorough examination was made on specially selected trees, and practically every inflorescence of two trees was removed and scrutinised in the laboratory. The results were much more satisfactory and yielded material sufficient to determine the development of the larval stages.

The first batch of larvæ was obtained on toon flowers on the 29th March, including a few early first stage individuals. Toon flowers were collected regularly from the middle of March onwards and records obtained of the progress of the generation. Throughout April, up till the 6th May, *robusta* larvæ of all stages were observed feeding in the inflorescences ; eggs were also obtained on the flowers. In the latter part of April mature fourth stage larvæ were most abundant, and after the 6th May larvæ of all stages, feeding on flowers, became scarce.



[To face page 22.

Experiments were carried out with the object of determining the number and length of the stadia of the larvæ of the first generation. The larvæ were reared from the earliest stages available in the field in various types of cages. The most suitable form of receptacle was found to be an earthenware jar about 4 inches high and 2 inches square closed with a muslin cover. Glass jars were tried, but discarded, as owing to the rapid evaporation of moisture from the inflorescences, given as food, moulds readily developed. The pottery jars maintained a more even dispersal of deposited moisture and prevented excessive growth of moulds. Too excessive evaporation was avoided by standing the jars in shallow trays containing about half an inch depth of water. The larvæ fed readily on the flowers supplied, and on reaching full size spun up cocoons inside the tangled mass of flower fragments and excreta. A tendency to restlessness before pupation was generally exhibited, indicating that the normal habit of pupation is not at the site of feeding.

The table below gives the relative development of the larval stages of 20 individuals of the first generation.

TABLE 3.—*Development of the Larval Stages of the First Generation, 1916.*

Individual Serial Number.	DATE OF ATTAINING TO LARVAL STAGE, 1916.					PUPAL STAGE.
	1st Stage.	2nd Stage.	3rd Stage.	4th Stage.	In Cocoon.	
1	March—29th .	March—31st .	April—2nd .	April—5th .	April—8th .	April—8th.
2	29th .	April—1st .	3rd .	5th .	7th .	8th
3	April—2nd .	5th .	7th .	9th .	12th .	13th.
4	2nd .	4th .	6th .	8th .	10th .	11th.
5	2nd .	6th .	8th .	10th .	13th .	13th.
6	2nd .	5th .	7th .	9th .	12th .	13th.
7	2nd .	3rd .	5th .	7th .	10th .	11th
8	2nd .	6th .	8th .	10th .	13th .	14th.
9	5th .	8th .	10th .	13th .	17th .	17th.
10	5th .	9th .	11th .	13th .	16th .	17th.
11	5th .	9th .	11th .	13th .	15th .	17th.
12	5th .	7th .	9th .	11th .	14th .	15th.
13	10th .	12th .	14th .	16th .	19th .	19th.
14	10th .	13th .	15th .	17th .	20th .	20th.
15	10th .	12th .	14th .	16th .	19th .	20th.
16	10th .	14th .	16th .	18th .	22nd .	22nd.
17	12th .	16th .	18th .	20th .	23rd .	24th
18	12th .	14th .	16th .	18th .	21st .	22nd.
19	12th .	15th .	17th .	19th .	22nd .	23rd.
20	12th .	14th .	16th .	18th .	22nd .	22nd.

The following table shows the actual number of days occupied by each of the larval stages during the feeding period of the above-mentioned individuals. The fourth stage includes the time occupied in the construction of the cocoon.

Table 4.—*Length of the Larval Stages of the First Generation, 1916.*

Individual Serial Number.	Number of days passed in				Length of Feeding period.
	1st Stage.	2nd Stage.	3rd Stage.	4th Stage.	
1	2	2	3	3	10
2	3	2	2	3	10
3	3	2	2	4	11
4	2	2	2	4	10
5	4	2	2	3	11
6	3	2	2	4	11
7	1	2	2	4	9
8	4	2	2	4	12
9	3	2	2	4	12
10	4	2	2	4	12
11	4	2	2	4	12
12	2	2	2	4	10
13	2	2	2	3	9
14	3	2	2	3	10
15	2	2	2	3	10
16	4	2	2	4	12
17	4	2	2	4	12
18	2	2	2	4	10
19	3	2	2	4	11
20	2	2	2	4	10

The first stage occupies on the average 2·85 days, the second stage 2·00 days, the third stage 2·10 days, and the fourth stage 3·70 days.

The length of the feeding period of the first generation larva is given in the last column of Table 4. The shortest length of the feeding period is 9 days and the longest 12 days ; the average of 20 records is 10·7 days. The larva takes 1—2 days in preparing the cocoon preparatory to pupation during which no food is taken. The majority of the first stage larvæ collected for the above experiment were 1—2 days old (*i.e.*, from hatching of the eggs) ; this amount should therefore be added to the length of the feeding period in captivity. The total normal length of the feeding period is therefore 9·7—10·7 days.

The colour changes in the instars of this generation, as observed in the feeding experiments of 1916 and again in 1917, are similar to those of the larvæ of the second generation (*vide* p. 28).

The seasonal history of this generation was not studied in the field in 1915, but in 1916 the swarming of the mature larvæ prior to pupation was determined by means of sack-band records. As the data for this generation are continuous with those of the second generation, they are given under that section (*vide infra* p. 32).

Pupae of the first generation.

1915. A few records, obtained in 1915, of the length of the pupal stage of the first generation, are given below.

TABLE 5.—*Length of Pupal Stage of First Generation, 1915.*

Number of Individuals.	Date of Pupation.	Date of Emergence.	Length of pupal period in days.
1	29th April	10th May	11
4	30th „	11th „	11
4	5th May	17th „	12

The average length of the pupal period is therefore 11·5 days. As regards field conditions, records show that on 29th April, live pupae and empty cocoons were found underneath the bark of old trees and a few mature larvæ were also observed wandering on the trunks. Larvæ and pupæ were collected at irregular intervals from the above date until the the 6th May. The majority of the cocoons obtained (over 2,000) contained empty pupal skins.

1916. In 1916 larvæ were bred up in the insectary and mature individuals were collected plentifully under sack-bands. The following table shows the dates of pupation and moth emergence of 47 individuals of the first generation.

TABLE 6.—*Length of the Pupal Stage of First Generation, 1916.*

Individual Serial Number.	Date of Pupation.	Date of Emergence.	Length of Pupal period in days.
	April—	April—	
1	8th	18th	10
2	8th	29th	11
3	13th	25th	12
4	12th	23rd	11
5	13th	23rd	10
6	13th	23rd	10
7	11th	21st	10
8	14th	25th	11
9	17th	29th	12
10	17th	28th	11
11	17th	28th	11
12	15th	25th	10
13	19th	30th	11
14	20th	30th	10
15	20th	28th	8
		May—	
16	22nd	2nd	11
17	24th	3rd	10
18	22nd	1st	10
19	23rd	4th	12
20	22nd	2nd	11

Individual Serial Number.	Date of Pupation.	Date of Emergence.	Length of Pupal period in days.
		April—	
21	19th . .	29th . .	10
22	19th . .	30th . .	11
23	20th . .	30th . .	10
24	19th . .	30th . .	11
25	19th . .	29th . .	10
26	20th . .	30th . .	10
27	19th . .	29th . .	10
28	19th . .	30th . .	11
29	18th . .	30th . .	12
30	18th . .	29th . .	11
31	19th . .	30th . .	11
32	20th . .	1st May .	11
		April—	
33	19th . .	29th . .	10
34	19th . .	30th . .	11
35	20th . .	30th . .	10
36	19th . .	30th . .	11
37	20th . .	1st May .	11
		April—	
38	19th . .	29th . .	10
39	18th . .	29th . .	11
40	20th . .	28th . .	8
41	20th . .	30th . .	10
42	19th . .	28th . .	9
43	20th . .	1st May .	11
		April—	
44	20th . .	29th . .	9
45	19th . .	29th . .	10
46	20th . .	30th . .	10
47	19th . .	30th . .	11

The shortest pupal period was 8 days and the longest 12 days, the average of 47 observations being 10·47 days with a mode of 11, thus:—eight days 2, nine days 2, ten days 19, eleven days 20, twelve days 4.

Moths of the First Generation.

1915. At the end of April 1915 cocoons were collected in large numbers from under the bark of toon trees, and the material yielded moths on the dates as given in the table below.

Table 7.—*Emergence of Moths of the First Generation, 1915.*

Date of Emergence.	Number of moths.	Date of Emergence.	Number of moths
April—		May—	
29th	5	5th . .	21
30th	20	6th . .	10
May—			
1st	36	8th . .	3
2nd	36	10th . .	1
3rd	29	11th . .	4
4th	21	17th . .	4

Since the number of cocoons collected was over 2,000 and the number of moths emerging was under 200, it is evident that only the later portion of the brood was represented and that the emergence of first generation moths actually commences much earlier than the 29th April. It is also probable that cocoons of the second generation were collected simultaneously with those of the first. This is borne out by the results obtained in 1916, in which year all of the individuals of definite broods were collected by means of sack-bands.

1916. The emergence records for 1916 are given in connection with those of the 2nd generation moths (*vide infra*, p. 41) from which it will be seen that the moths of the first generation begin to appear on 8th April and emergence continues until about the 1st May and that the two broods overlap.

2. THE SECOND GENERATION.

Larvae of the second generation.

1914. On the 12th May, 1914, young and half grown larvæ were detected for the first time feeding inside ripe and semi-ripe fruits. From this date fruits were regularly collected from trees known to be affected, and moths were successfully bred out in May and June. No observations were made on the larval development.

1915. Throughout the month of May, 1915, all stages of the larvæ and pupæ of the toon moth were met with in the field. On the 14th May, it was observed that swarming was fairly general and that the majority of broods were mature.

Experiments were carried out in the insectary to determine the lengths of the larval and pupal stages, and of the feeding period, and to observe the feeding habits. The larvæ were confined in separate pottery jars, similar to those used for the experimental work on the first, or flower generation. Toon fruits were given singly to each larva, and replaced when the edible portions had been consumed. A constant degree of humidity was maintained by standing the pots in a shallow depth of water; without the artificial production of the necessary humidity it was found that the fruits dried up rapidly and were abandoned by the larvæ. The larvæ fed voraciously and attacked fresh fruits within a few minutes of receipt. On reaching full size, the larvæ constructed a cocoon of silk in a corner of the pot or in the folds of the muslin cover.

The following statement shows the relative development of

Table 8.—*Development and colour changes of larvæ*

No.	8th May.	10th May.	12th May.
1	3rd stage, reddish brown .	4th stage, pinkish brown with blue.	Larva in cocoon, bluish green.
2	2nd stage, brown . .	2nd stage, brown . .	3rd stage, reddish brown .
3	3rd stage, reddish brown .	4th stage, pinkish blue .	Larva in cocoon, bluish green
4	2nd stage, brown . .	3rd stage, reddish brown .	4th stage, pinkish blue .
5	2nd stage, light brown .	3rd stage, brown . . .	4th stage, fading brown .
6	Do. . .	Do. . . .	4th stage, pinkish brown .
7*a* & 7*b*	2nd and 3rd stages, brown and dark brown.	3rd and 4th stages, dark brown and reddish brown.	4th stage and larva in cocoon, pinkish brown and greenish blue.
8	2nd stage, light brown .	3rd stage, reddish brown .	4th stage, pinkish blue .
9*a* & 9*b*	2nd and 3rd stages, light brown and brown.	2nd and 4th stages, reddish brown and light blue.	3rd stage, reddish brown ; the other escaped.
10	2nd stage, pale brown . .	2nd stage, light brown .	3rd stage, reddish brown .
11	3rd stage, reddish brown .	4th stage, reddish brown with blue.	Larva in cocoon, bluish green
12	3rd stage, brown . . .	4th stage, bluish brown .	Do.
13	Do. . . .	4th stage, pinkish brown .	Larva in cocoon, greenish blue.
14	3rd stage, pale brown . .	4th stage, light purple brown	Do.
15	3rd stage, brown . . .	4th stage, bluish brown .	Larva in cocoon, pinkish blue
16	3rd stage, light brown . .	4th stage, pinkish brown .	Larva in cocoon, bluish green
17	2nd stage, light brown .	3rd stage, reddish brown .	4th stage, fading brown .
18	3rd stage, brown . . .	4th stage reddish brown .	Larva in cocoon, bluish green
19	Do. . . .	Do. do. . .	Larva in cocoon, greenish blue
20*a* & 20*b*	2nd and 3rd stages, pale and brown.	3rd and 4th stages, brown and pinkish blue.	(*a*) Bluish green . . . (*b*) 4th stage, larva in cocoon
21*a* & 21*b*	Do. . . .	3rd and 4th stages, brown and bluish green.	(*a*) Bluish green . . . (*b*) 4th stage, larva in cocoon
22	3rd stage, brown . . .	4th stage, purple . .	Larva in cocoon, bluish green
23	Do. . . .	4th stage, reddish brown with blue.	Larva in cocoon, greenish blue
24*a* & 24*b*	2nd and 3rd stages, light brown and brown. .	3rd and 4th stages, reddish brown and bluish brown.	(*a*) Greenish blue . . (*b*) 4th stage and larva in cocoon
25*a* & 25*b*	Do. . . .	3rd and 4th stages, brown and pinkish blue.	3rd stage, greenish blue and larva in cocoon.
26	1st stage, straw colour .	1st stage, pale . . .	2nd stage, light brown .
27	4th stage, purple . .	Larva in cocoon, bluish green	Pupated . . .
28	3rd stage, brown . . .	4th stage, fading brown .	Larva in cocoon, pinkish blue
29	Do. . . .	4th stage, pinkish blue .	Larva in cocoon, greenish blue
30*a* & 30*b*	2nd and 3rd stages, brown .	3rd and 4th stages, reddish brown and bluish brown.	4th stage, greenish blue, larva in cocoon.
31	1st stage, straw colour . .	1st stage, straw colour .	2nd stage, light brown . .
32	3rd stage, brown . . .	4th stage, fading pinkish brown. .	Larva in cocoon, greenish blue
33*a* & 33*b*	1st and 2nd stages, pale brown. .	1st and 3rd stages, brown .	2nd and 4th stages, brownish red and pinkish blue.
34	3rd stage, brown . . .	4th stage, fading brown .	Larva in cocoon, bluish green
35	2nd stage, light brown .	3rd stage, brown . . .	4th stage, bluish brown .
36	1st stage, pale brown . .	1st stage, light brown . .	2nd stage, brownish . .
37	....	....	1st stage, light brown . .
38	....	....	....
39	....	....	2nd stage, brownish . .
40	3rd stage, brown . . .	4th stage, fading brown .	Larva escaped . .

40 individuals and the accompanying colour changes.

of the 2nd Generation, 1915.

14th May.	16th May.	17th and 18th May.	20th May.
Pupated	Pupa	Pupa	Pupa.
4th stage, fading brown	Larva in cocoon, greenish blue.	Pupated	Do.
Pupated	Pupa	Pupa	Do.
Larva in cocoon, bluish green	Pupated	Do.	Do.
Do. do.	Do.	Do.	Do.
Do. do.	Do.	Do.	Do.
(*a*) Larva in cocoon	(*a*) Pupated	Do.	Do.
(*b*) pupated, bluish green	(*b*) Pupa	Do.	Do.
Pupated	Pupa	Do.	Do.
4th stage, fading pinkish brown with blue.	Larva in cocoon, bluish green.	Pupated	Do.
4th stage, bluish green	Do.	Do.	Do.
Pupated	Pupa	Pupa	Do.
Do.	Do.	Do.	Do.
Do.	Do.	Do.	Do.
Do.	Do.	Do.	Do.
Do.	Do.	Do.	Do.
Do.	Do.	Do.	Do.
Escaped	....	....	..
Pupated	Pupa	Pupa	Pupa.
Do.	Do.	Do.	Do.
(*a*) Larva in cocoon	(*a*) Pupated	Do.	Do.
(*b*) Pupated	(*b*) Pupa	Do.	Do.
(*a*) Larva in cocoon	Do.	Do.	Do.
(*b*) Pupated	Do.	Do.	Do.
Pupated	Do.	Do.	Do.
Do.	Do.	Do.	Do.
(*a*) Larva in cocoon	Do.	Do.	Do.
(*b*) Pupated	Do.	Do.	Do.
(*a*) 3rd stage	(*a*) Died as larva	....	..
(*b*) Pupated	(*b*) Pupa	Pupa	Pupa.
3rd stage, brown	3rd stage, brown	4th stage, fading brown.	Larva in cocoon on 19th; pupated 20th May.
Pupa	Pupa	Pupa	Pupa.
Pupated	Do.	Do.	Do.
Do.	Do.	Do.	Do.
Larva in cocoon	Pupated	Do.	Do.
Pupated	Pupa	Do.	Do.
3rd stage, brown	4th stage, fading brown.	Larva in cocoon, greenish blue.	Pupated.
Pupated	Pupa	Pupa	Pupa.
3rd stage, reddish brown	4th stage, fading brown	Larva in cocoon	Pupated.
Larva in cocoon	Pupated	Pupa	Pupa.
Pupated	Pupa	Do.	Do.
Larva in cocoon, bluish green	Pupated	Do.	Do.
3rd stage, reddish brown	4th stage fading brown	Pupated bluish green	Do.
2nd stage, brown	3rd stage, reddish brown	4th stage, pink blue	Do.
4th stage, bluish green	Larva in cocoon	Pupated	Do.
2nd stage, brown	3rd stage, reddish brown	4th stage, bluish green.	Pupated.
....	....	....	..

From the records given above, it is evident that the development of the larva of the 2nd generation is relatively rapid, and that there are 3 moults before pupation. The time taken to pass from the first to the second stage is 4 days ; from the second stage to the third, 2 days ; from the third stage to the fourth, 2 days ; and from the fourth stage to the pupa, 4 days. The time required for the construction of the silk cocoon in which the larva pupates is 1 to 2 days. The feeding period of the larva varies from 9 to 11 days, *vide* examples 26, 31, 33*a*, and 36 in Table 8. A period of about 1 to 2 days should be allowed for the interval between hatching and collection in the field, which gives a total feeding period for the larva of this generation, as approximately 10—13 days.

Number of fruits eaten by a single larva.

On the 10th May 1915, a typically attacked panicle of fruits was collected and examined ; it was found to contain—

4	full-grown	bluish green, 4th stage larvæ.
4	,, ,,	reddish green, 3rd stage larvæ.
7	,, ,,	brown, 2nd stage larvæ.
2	,, ,,	pale brown, 1st stage larvæ.

The number of attacked and completely eaten fruits in the bunch was 57. The larvæ from this source were kept in a cage with 17 fresh fruits. On examination three days later, on the 13th May, it was found that 4 larvæ had pupated, and that out of the 17 fruits, 13 were completely consumed. Ten fresh fruits were added. By the 19th May, all larvæ except one had pupated, and out of the 10 fruits 9 were completely devoured, and the 10th partially eaten. Thus 17 larvæ ate in all 90 fruits, *i.e.*, an average of 5—6 fruits per head.

Swarming of the 2nd Generation Larvæ.

In May 1915, it was realised that *robusta* larvæ which have completed their development in toon fruits normally display a tendency to migration, in the search for suitable places in which to pupate. Under ordinary conditions pupation occurs in crevices, or under flakes of the bark of the tree on which they have fed. Attempts were, therefore, made to obtain incidence data by means of artificially induced pupation in bands of sacking, folded double and tied to the trunk of the tree with twine. Some 335 toon trees in avenues and gardens in Dehra Dun were banded at various dates in May 1915, and collections of mature larvæ and cocoons were carried out when pressure of other work permitted. Four localities were selected, *viz.* :—Locality I, 67 trees banded on the 12th, 15th and 18th May ; Locality II, 188 trees banded 19th—28th May ; Locality

III, 42 trees banded 19th—20th May; Locality IV, 38 trees banded 18th May.

The results obtained are shown in the table below :—

TABLE 9.—*Records of Larvæ and Cocoons collected at Sack-bands in 1915.*

Date of collection.	NUMBER OF LARVÆ OR COCOONS COLLECTED.			
	LOCALITY 1.	LOCALITY 2.	LOCALITY 3.	LOCALITY 4.
	67 trees banded 12th, 15th, 18th May.	188 trees banded 19th, to 28th May.	42 trees banded 19th, 20th May.	38 trees banded 18th May.
May—				
18th . . .	775	..	..	..
19th . . .	395	..	..	..
20th . . .	980	..	..	..
21st . . .	458	..	..	..
22nd . . .	400	...	...	..
23rd . . .	257	..	..	..
24th . . .	200	..	..	296
25th . . .	32	..	..	..
26th . . .	..	..	..	..
27th . . .	51	..	278	..
28th . . .	..	..	..	..
29th . . .	..	..	..	..
30th . . .	..	..	..	..
31st . . .	..	769	1	..
June—				
1st . . .	..	66	35	..
2nd . . .	..	50	..	..
3rd . . .	..	..	..	..
4th . . .	..	..	..	83
5th . . .	..	..	..	..
6th . . .	..	..	..	..
7th . . .	..	21	..	..
8th . . .	2	..	9	..
9th . . .	..	..	..	..
10th . . .	..	..	..	..
11th . . .	..	..	..	..
12th . . .	..	..	..	..
13th . . .	..	..	..	..
14th . . .	..	..	..	..
15th . . .	..	..	..	..
16th . . .	..	..	..	..
17th . . .	..	..	..	..
18th . . .	..	..	..	..
19th . . .	..	..	..	..
20th . . .	..	..	..	..
21st . . .	..	..	..	..
22nd . . .	..	..	..	..
23rd . . .	..	..	..	..
24th . . .	..	..	..	..

It is evident that the sack-bands were put out far too late to obtain more than the latest swarms of this generation, and that on a few trees only was more than a very small proportion of the caterpillars caught. Out of the 335 trees banded, 163 trees failed to produce any larvæ or cocoon. If the figures are arranged slightly differently, this is still more evident, *i.e.*—

Time when banded.	Average number caught per tree.
May—	
12th	218
15th	7
18th	7
19th	9
20th	8
22nd	2
24th	1·5
25th	1·2
26th	·4
27th	·4
28th	·2
June	·0

It is now clear that the earliest bands were put out two to three weeks too late, and that to ensure catching the first individuals of the second generation, bands should be on the trees prior to the 15th April.

1916. In 1916 it was resolved, in consequence of the experience of the previous year, to determine the seasonal activity of the mature larvæ of both the first, or flower, and the second, or fruit, generations, by continuous sack-band records throughout the hot weather. Owing to unforeseen difficulties in the supply of labour and opposition on the part of the owners of toon trees, the sack—banding was unavoidably delayed in some localities beyond the commencement of the swarming season of the first generation larvæ. The data obtained, however, are relatively complete and permit of judicious interpretation. In all, 898 toon trees were banded over an area of some 3 square miles. Records were kept separately for localities, *viz.* :—Locality I, 100 trees banded on the 13th and 14th March ; Locality II, 538 trees banded on the 15th—18th and 21st March ; Locality III, 225 trees, banded on the 9th and 12th April ; Locality IV, 35 trees banded on the 9th April. The trees were serially numbered and visited daily (with a few exceptions) during April and May 1916 by parties consisting each of one trained collector and one or two coolies. The larvæ and cocoons collected on each tree were counted on the spot, and brought in sealed boxes to the insectary for breeding purposes. The following table gives the records for each area :—

Table 10.—*Sack-band Records of Swarming Larvæ of First and Second Generations, Dehra Dun, April and May 1916.*

Locality I.	Number of trees banded.	Time when banded.	Time of collection.	Number collected.
Research Institute Compound.	100	13th, 14th March.	March 31st .	224
			April—	
			1st . .	Not examined.
			2nd . .	Do.
			3rd . .	Do.
			4th . .	Do.
			5th . .	756
			6th . .	535
			7th . .	Not examined.
			8th . .	903
			9th . .	Not examined.
			10th . .	999
			11th . .	Not examined.
			12th . .	856
			13th . .	229
			14th . .	113
			15th . .	65
			16th . .	Not examined.
			17th . .	20
			18th . .	Not examined.
			19th . .	Do.
			20th . .	4
			21st . .	..
			22nd . .	..
			23rd . .	..
			24th . .	..
			25th . .	..
			26th . .	..
			27th . .	..
			28th . .	..
			29th . .	..
			30th . .	..
			May—	
			1st . .	..
			2nd . .	..
			3rd . .	..
			4th . .	185
			5th . .	95
			6th . .	191
			7th . .	208
			8th . .	185
			9th . .	216
			10th . .	154
			11th . .	75
			12th . .	49
			13th . .	167
			14th . .	Not examined.
			15th . .	118
			16th . .	109
			17th . .	91

Table 10—*contd.*

Locality I.	Number of trees banded.	Time when banded.	Time of collection.	Number collected.
Research Institute Compound.	100	13th, 14th March.	March 31st .	..
			May—	Not examined.
			18th . .	31
			19th . .	28
			20th . .	33
			21st . .	16
			22nd . .	22
			23rd . .	18
			24th . .	5
			25th . .	..
			26th . .	..
			27th . .	..
			28th . .	..
			29th . .	..
			30th . .	..
			31st . .	..

In the above area, out of 100 trees banded 41 trees produced no larvæ in the first generation, although all flowered normally. In the second generation only 4 trees remained unattacked, although the intensity of attack in the locality as a whole was very much reduced.

Table 11.—*Sack-band Records of Swarming Larvæ of First and Second Generations, Dehra Dun, April and May, 1916.*

Locality II.	Number of trees banded.	Time when banded.	Time of collection.	Number collected.
Kaunli and adjoining gardens.	538	15th, 18th and 21st March.	March 31st .	446
			April—	
			1st . .	2,042
			2nd . .	Not examined.
			3rd . .	1,453
			4th . .	1,402
			5th . .	2,686
			6th . .	5,156
			7th . .	4,260
			8th . .	5,059
			9th . .	Not examined.
			10th . .	6,462
			11th . .	3,503
			12th . .	337
			13th . .	1,904
			14th . .	1,924
			15th . .	1,124
			16th . .	384
			17th . .	589
			18th . .	431
			19th . .	314
			20th . .	140
			21st . .	39

TABLE 11—*contd.*

Locality II.	Number of trees banded.	Time when banded.	Time of collection.	Number collected.
Kaunli and adjoining gardens.	538	15th, 18 and 21st March.	March 21st .	..
			April—	Not examined.
			22nd . .	9
			23rd . .	34
			24th . .	19
			25th . .	90
			26th . .	18
			27th . .	27
			28th . .	57
			29th . .	25
			30th . .	47
			May—	
			1st . .	87
			2nd . .	57
			3rd . .	392
			4th . .	650
			5th . .	982
			6th . .	1,514
			7th . .	1,087
			8th . .	945
			9th . .	1,161
			10th . .	862
			11th . .	766
			12th . .	729
			13th . .	588
			14th . .	845
			15th . .	637
			16th . .	592
			17th . .	490
			18th . .	431
			19th . .	329
			20th . .	279
			21st . .	231
			22nd . .	182
			23rd . .	131
			24th . .	130
			25th . .	..
			26th . .	...
			27th . .	..
			28th . .	..
			29th . .	..
			30th . .	..
			31st . .	..

In this locality out of 538 trees banded only 47 remained unaffected in the first generation, while in the second generation this was reduced to 4. It will be observed that no collections were made on the 2nd and 9th April, and a partial collection was made on the 12th April, due to miscalculation in the number of the collecting staff required. These discrepancies have been obviated by plotting the swarming curve on ordinates based on the series of progressive daily totals, and not on the actuals of each day.

Table 12.—*Sack-band Records of Swarming Larvæ of First and Second Generations, Dehra Dun, April and May, 1916.*

Locality III.	Number of trees banded.	Time when banded.	Time of collection.	Number collected.
			April—	
Chakrata Road .	225	9th and 12th April.	18th . .	2,015
			19th . .	478
			20th . .	120
			21st . .	64
			22nd . .	71
			23rd . .	29
			24th . .	43
			25th . .	Not examined.
			26th . .	41
			27th . .	29
			28th . .	31
			29th . .	81
			30th . .	75
			May—	
			1st . .	120
			2nd . .	262
			3rd . .	559
			4th . .	839
			5th . .	911
			6th . .	960
			7th . .	641
			8th . .	557
			9th . .	703
			10th . .	372
			11th . .	288
			12th . .	344
			13th . .	279
			14th . .	282
			15th . .	196
			16th . .	208
			17th . .	207
			18th . .	255
			19th . .	156
			20th . .	92
			21st . .	93
			22nd . .	51
			23rd . .	34
			24th . .	29
			25th . .	..
			26th . .	..
			27th . .	..
			28th . .	..
			29th . .	..
			30th . .	..
			31st . .	..

The sack-bands on the trees in Locality III were put up rather late, and consequently the initial collections represent the accumulated pupations of an unknown number of days previously. In constructing the curve in Plate VI this has been recognised Out of a total of 225 trees banded, only 14 remained unaffected during the first generation, while in the fruit generation all trees yielded *robusta* larvæ.

Table 13.—*Sack-band Records of Swarming Larvæ of First and Second Generations, Dehra Dun, April and May, 1916.*

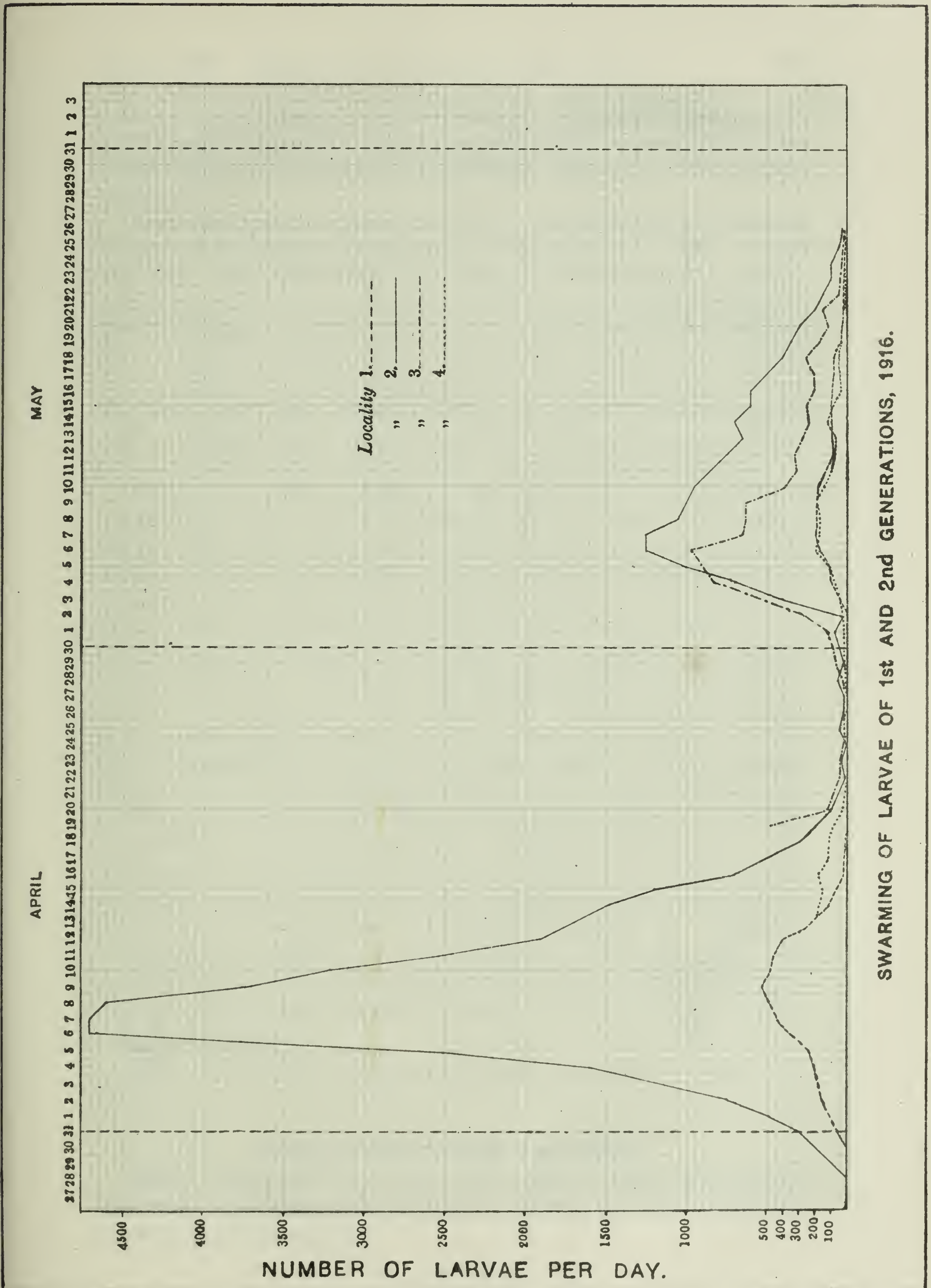
Locality IV.	Number of trees banded.	Time when banded.	Time of collection.	Number collected.
			April—	
Cantonment Road	35	9th April .	12th . .	1,480
			13th . .	201
			14th . .	Not examined.
			15th . .	308
			16th . .	183
			17th . .	108
			18th . .	84
			19th . .	169
			20th . .	15
			21st . .	18
			22nd . .	17
			23rd . .	31
			24th . .	14
			25th . .	20
			26th . .	14
			27th . .	11
			28th . .	13
			29th . .	21
			30th . .	21
			May—	
			1st . .	30
			2nd . .	33
			3rd . .	46
			4th . .	96
			5th . .	62
			6th . .	248
			7th . .	159
			8th . .	174
			9th . .	209
			10th . .	165
			11th . .	94
			12th . .	86
			13th . .	69
			14th . .	120
			15th . .	70
			16th . .	47
			17th . .	49
			18th . .	52
			19th . .	34
			20th . .	34
			21st . .	26
			22nd . .	11
			23rd . .	9
			24th . .	14
			25th . .	..
			26th . .	..
			27th . .	..
			28th . .	..
			29th . .	1
			30th . .	..
			31st . .	..

As the sack-bands were put up too late, in this area, the earlier swarms were not obtained. All the trees in this area showed *robusta* attack. In the following table the records of the four localities are amalgamated.

Table 14.—*Larvæ and Pupæ collected from Sack-bands, Dehra Dun, April—May, 1916.*

Time of collection.	Total collection.	Time of collection.	Total collection.
		May—	
March—			
31st	670	1st	237
April—			
1st	2,040	2nd	352
2nd	Not examined.	3rd	997
3rd	1,453	4th	1,770
4th	1,402	5th	2,050
5th	3,442	6th	2,913
6th	5,691	7th	2,095
7th	4,260	8th	1,861
8th	5,962	9th	2,289
9th	Not examined.	10th	1,553
10th	7,461	11th	1,223
11th	3,503	12th	1,208
12th	2,673	13th	1,103
13th	2,334	14th	1,247
14th	2,037	15th	1,021
15th	1,497	16th	956
16th	467	17th	837
17th	717	18th	769
18th	2,530	19th	547
19th	961	20th	438
20th	279	21st	366
21st	121	22nd	266
22nd	98	23rd	182
23rd	94	24th	178
24th	76	25th	..
25th	110	26th	..
26th	73	27th	..
27th	67	28th	..
28th	101	29th	..
29th	127	30th	..
30th	143	31st	..
		Grand Total	76,849

In Plate VI are given curves for the swarming of the larvæ of the first and second generations, constructed, firstly, by plotting the points of the *actual* progressive daily totals of larvæ, etc., collected, and constructing a regular curve through these points ; and, secondly, by reading off from this curve the *theoretical* progressive daily totals ; and, thirdly, by calculating by difference from the figures so obtained, the theoretical



SWARMING OF LARVAE OF 1st AND 2nd GENERATIONS, 1916.

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value of the daily figures. By this means the errors of the actual records, due to inequality in daily collection, are eliminated without affecting the general value of the curve as determined by date and meteorological conditions.

From the Tables 10—14 and Plate VI, it will be seen that the swarming of larvæ of *H. robusta* is fairly general throughout the months of April and May. The curves reach their summits between the 6th and 9th April and again between the 6th and 9th May, about one month later. From the beginning of the fourth week in April until the beginning of May, the daily numbers remain low and steady, which points strongly to an overlap of the extreme limits of the first and second generations. The larvæ and pupæ collected under sack-bands during this period belong, therefore, partly to the latest broods of the first (flower) generation, and partly to the earliest broods of the second (fruit) generation.

During the month of April, 77·5 per cent. of the total number of banded-trees were attacked, while in May 90·2 per cent. were attacked. On the other hand, the average number of larvæ per tree during the flower generation is 63, while the average number per tree during the fruit generation is 33. It is believed that this reduction in the incidence of 47·6 per cent. is the direct result of the destruction of the larvæ, etc., of the first generation caught at sack-bands, and is suggested as a possible method of control. The normal rate of increase of the first two generations is very much greater than that of the 3 later generations, owing to the greater supply of food (*i.e.*, 5 or 6 fruits per head suffice in the one case, against 1 or 2 shoots per head in the other). It is even possible that there is normally a *decrease* in the absolute numbers of the insect in the last three generations. The result of sack-banding is to start the 3rd generation at a very much lower incidence than the normal. If x is the factor representing the normal rate of increase and y the incidence of the 5th generation, then the initial incidence of the 3rd generation is reduced by sack-banding from yx^2 to $y(\frac{47 \cdot 6}{100})^2$=roughly $\frac{y}{4}$. Similarly in Locality II, where the sack-banding was most successful, the incidence is reduced from 39,852 (=74 per tree) to 14,256 (=26·5 per tree) *i.e.*, 35·7% ; here the initial incidence of the 3rd generation is $y\ (\frac{35 \cdot 7}{100})^2$=roughly $\frac{y}{7}$.

1917. In 1917 the swarming of larvæ continued up to the 10th June.

Pupae of the Second Generation.

1914. During May and early June, matured larvæ feeding inside toon fruits were collected for preliminary work on the pupal stages, and the following data recorded.

Table 15.—*Length of the Pupal Stage of the Second Generation, 1914.*

Individual Serial Number.	Date of Pupation.	Date of Emergence.	Length of Pupal Period in days.
	May—	May—	
1	3rd . .	19th . .	15
2	10th . .	27th . .	16
		June—	
3	18th . .	3rd . .	15
4	20th . .	5th . .	15
5	25th . .	11th . .	16
	June—		
6	2nd . .	18th . .	15
7	5th . .	19th . .	13

The above records indicate that pupation commences as early as the 3rd of May, and continues until the 5th of June. The shortest length of the pupal period is 13 days and the longest 16 days ; the average length on 7 observations is 15 days.

1915. During the season of 1915, more material was available for the experimental determination of the pupal period of this generation. Mature larvæ were obtained by trapping in sack-bands during the month of May. The table immediately following shows the data recorded for 50 individuals selected from the sack-band material.

Table 16.—*Length of the Pupal Stage of the Second Generation, 1915.*

Individual Serial Number.	Date of Pupation.	Date of Emergence.	Individual Serial Number.	Date of Pupation.	Date of Emergence.
	May—	May—		May—	May—
1	14th .	26th.	28	14th .	27th.
2	17th 18th	29th 30th.	29	20th .	31st.
3	14th .	26th	30	12th .	24th.
4	16th .	27th.	31	14th .	27th.
5	16th .	28th.	32	14th .	26th.
6	16th .	28th.	33	14th .	28th.
7	14th .	27th.	34	16th .	27th
8	16th .	28th.	35	20th .	1st June.
9	14th .	26th.			May—
10	17th 18th	29th.	36	14th .	26th.
11	17th .	29th.	37	16th .	20th.
12	14th .	26th.			June—
13	14th .	26th.	38	20th .	2nd
14	14th .	26th.	39	14th .	26th May.
15	14th .	26th	40	16th .	29th.
16	14th .	26th	41	17th 18th	1st June.
17	14th .	27th	42	20th .	1st.
18	14th .	26th	43	17th, 18th.	31st May.
19	14th .	28th.	44	20th .	3rd June

TABLE 16—*contd.*

Individual Serial Number.	Date of Pupation.	Date of Emergence.	Individual Serial Number.	Date of Pupation.	Date of Emergence
	May—	May—		May—	May—
20	14th .	27th.			
21	16th .	28th.	45	13th	25th.
22	14th .	27th.	46	13th .	26th.
23	16th .	28th.	47	19th .	31st.
24	14th .	29th.	48	15th .	29th.
25	14th .	27th.	49	15th .	28th.
26	14th .	29th.	50	19th .	1st June.
27	16th .	28th.			

The data given above show that the shortest pupal period is of 11 days and the longest of 15 days ; the average of 50 observations is 13 days but the mode is 12 days (see Table 17).

TABLE 17.—*Variation and Frequency of the Pupal Period of the Second Generation, 1915.*

Length of Pupal Period in days.	Number of times occurring.
11	3
12	29
13	13
14	6
15	3

Moths of the Second Generation.

1914. Moths of the second generation were bred out in May and June 1914 from larvæ feeding on fruits collected in the middle of May (see Table 18 below).

TABLE 18.—*Emergence of Moths of the Second Generation 1914.*

Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
May—		June—	
19th . . .	1	3rd . . .	11
26th . . .	6	5th . . .	16
27th . . .	1	6th . .	1
28th . . .	21	8th . . .	1
29th . . .	26	18th . . .	1
June—			
1st . . .	10	19th . . .	1
2nd . . .	11		

Out of a total of 107 moths, the majority emerged between the 28th May and 5th June ; the period of emergence extended from the 19th May to the 19th June, but as subsequent records show this does not represent the maximum extent of the normal emergence period for this generation.

1915. The evidence obtained in the following year 1915 is founded on material collected under sack-bands put out on 335 trees in the neighbourhood of Dehra Dun. The cocoons were collected from the sack-bands at regular intervals and kept in glass box-form breeding cages in the insectary. The amalgamated emergence records are given in Table 19.

Table 19.—*Emergence of Moths of the Second Generation, 1915.*

Time of Emergence.	Total Emergence.	Time of Emergence.	Total Emergence.
May—		June—	
18th . . .	4	2nd . . .	36
19th . . .	4	3rd . . .	85
20th . . .	6	4th . . .	51
21st . . .	21	5th . . .	55
22nd . . .	16	7th . . .	10
24th . . .	14	8th . . .	63
25th . . .	31	9th . . .	5
26th . . .	37	10th . . .	8
27th . . .	72	12th . . .	1
28th . . .	43	14th . . .	1
31st . . .	55	16th . . .	1
June—		18th . . .	3
1st . . .	41	19th . . .	5

The earliest records for second generation moths obtained this year is the 18th of May and the latest the 19th of June, with the maximum emergence between the 25th May and the 18th June, which agrees generally with the records of 1914. The true extent of the generation is, however, not represented, as from experiments carried out in 1916, it is evident that the sack-bands were put up a fortnight to three weeks too late to secure the earliest individuals of the brood. Moreover, the number of moths reared is a very small proportion of the total number of cocoons collected ; the mortality is due to two causes : (*a*) a large number of mature larvæ and cocoons was reared in wire cages in the open and heavy rainfall on one night swamped the cages and drowned over 3,000 insects ; and, (*b*) owing to overcrowding of cocoons in glass-sided cages a very large percentage of moths died in the act of emergence. It was found that if large numbers of larvæ are confined in small cages, they spin a very dense network of silk webbing while wandering about the cages, so that the sides of the cage and the cocoons of previously pupated individuals are covered with impenetrable sheets of silk several layers deep. The moth when ready to emerge is unable to pass through the silk webbing and dies without effecting emergence.

1916. Special attention was paid to the elimination of this difficulty when repeating the rearing operations in 1916. Collections of larvæ and cocoons were made daily in March, April and May from about

898 sack-banded trees in the vicinity of Dehra Dun. The material obtained on each tree was counted on the spot, and brought in sealed boxes to the insectary and distributed in more than 100 separate breeding cages. Facilities for pupation were given in the form of rolls and spirals of stiff paper and folded sheets of corrugated packing-cardboard. The tendency to wander and spin silk was much reduced, but in spite of all precautions a large proportion of the insects died as a result of rough-handling and overcrowding. Out of a total of about 77,000 larvæ and pupæ collected under sack-bands (representing both the first and the second generations), only 30,848 moths emerged successfully in the rearing cages. Over 28,000 larvæ and pupæ were counted dead inside the cages at the close of the experiment and the remainder were either parasitised or died as moths in the cocoons. The conditions producing mortality among larvæ, pupæ and moths, however, were constant throughout the period of the experiment and the actual emergences recorded may, therefore. be taken as an approximately correct indication of the seasonal history of the two generations.

As the flight periods of the first and second generations overlap, the emergence records of both are given in one table. (see Table 20).

TABLE 20.—*Emergence of Moths of the First and Second Generations, from Material collected under Sack-bands, Dehra Dun 1916.*

Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
April—		April—		May—	
8th . .	30	28th . .	48	18th . .	628
9th . .	57	29th . .	7	19th . .	875
10th . .	115	30th . .	4	20th . .	874
		May—			
11th . .	237	1st . .	29	21st . .	669
12th . .	814	2nd . .	9	22nd . .	526
13th . .	1,645	3rd . .	3	23rd . .	313
14th . .	1,476	4th . .	10	24th . .	119
15th . .	1,454	5th . .	22	25th . .	168
16th . .	2,471	6th . .	49	26th . .	102
17th . .	2,979	7th . .	47	27th . .	49
18th . .	2,393	8th . .	92	28th . .	18
19th . .	2,137	9th . .	116	29th . .	6
20th . .	2,027	10th . .	119	30th . .	25
21st . .	1,558	11th . .	89	31st . .	3
				June—	
22nd . .	1,259	12th . .	139	1st . .	2
23rd . .	848	13th . .	326	2nd . .	4
24th . .	817	14th . .	495	3rd . .	...
25th . .	429	15th . .	467	4th . .	1
26th . .	296	16th . .	523	5th . .	1
27th . .	123	17th . .	644	6th . .	..

From Table 20 it will be seen that emergence of the first generation commenced on the 8th April and that of the second generation concluded on the 5th June. The maximum emergence periods occur from the 11th April to the 25th April, and again from about the 11th May to the 25th May. Between the 29th April and the 5th May, there is an evident overlap of the two emergence periods, and it is impossible to assign with certainty moths caught at this period to either generation. Plate VII shows the curve of emergence of both generations constructed geometrically from the curve of progressive daily totals, which may be considered to represent, with fair accuracy, the normal emergence curve of the species in the locality of Dehra Dun. It must, however, be remembered that the numbers of the second generation as compared with those of the first generation are relatively much reduced, owing to the local destruction of a large percentage of the first brood individuals as a result of sack-banding. The two curves represent, therefore, not the comparative incidence, but the comparative periodic occurrence of the two broods.

Connection between the 1st-2nd and 3rd-5th Generations.

In order to determine if, and to what extent, saplings and young non-flowering trees are attacked by the 1st and 2nd generations two observation areas were selected in 1916. On the 4th February, 99 trees in Locality 1 and 164 trees in Locality 2 were examined, and all infested shoots pruned and destroyed. The percentage of attack (by the 5th generation) in the first locality was 68, and in the second 93.

During the period of the flower and fruit broods, the trees were examined at intervals to discover, if any of the shoots showed signs of attack ; all trees were found to be immune. On the 20th June, no attack was located in the first locality ; but a few shoots were found to be bored in the second locality, on the 20th July the borer had appeared in both localities.* Examination at later dates showed a higher degree of infestation in the second area, probably because the first locality was not far distant from the experimental area in which sack-bands had been put up.

The converse of this was observed at the end of July, 1914, when opportunity occurred to examine the crown of several felled mature toon trees. No attack was found except in a few soft epicormic shoots ; the majority of twigs in the crown of old trees are too hard and the season's growth too short to be suitable for the development of 3rd and later brood larvæ.

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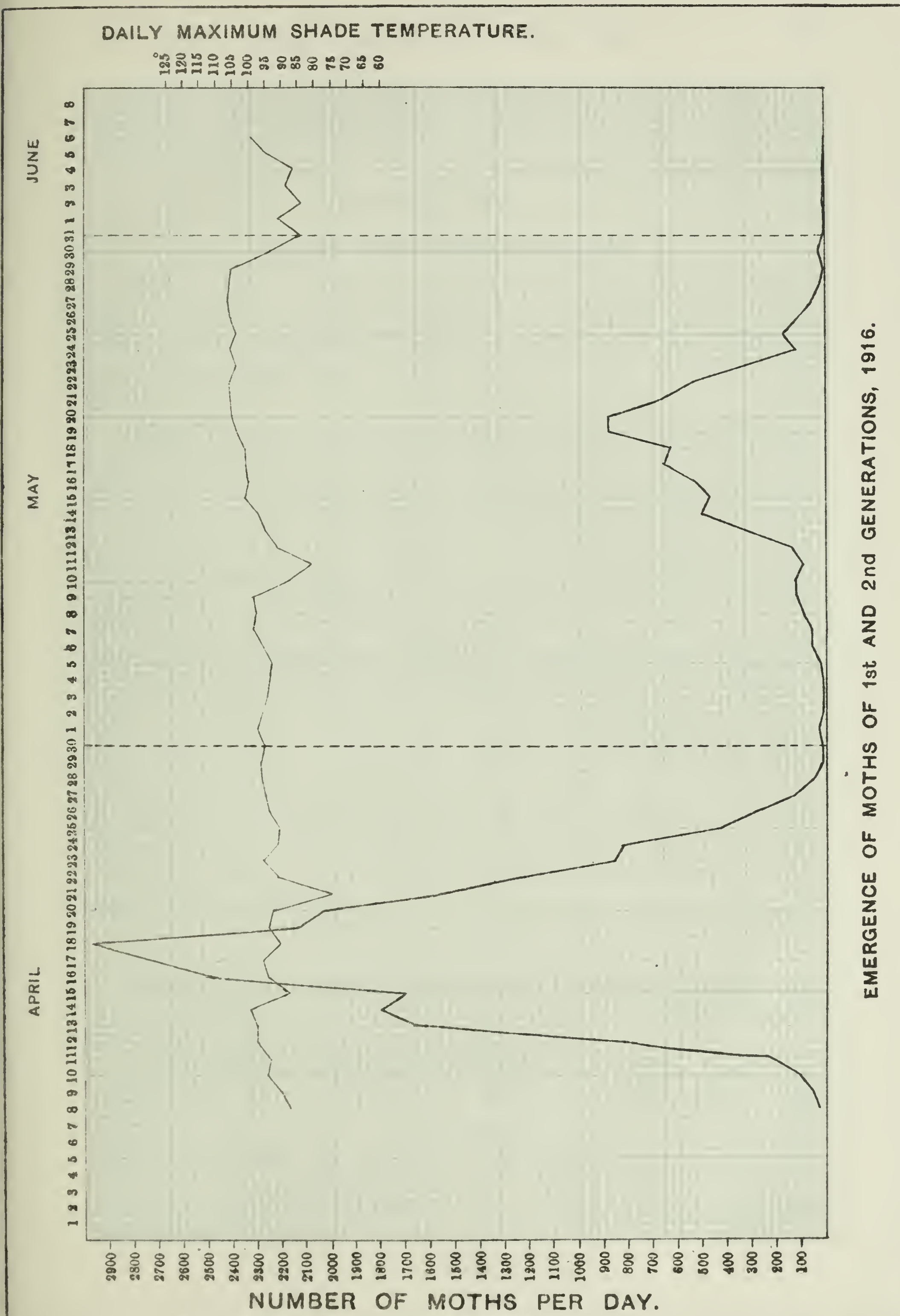
* In May, 1914, numerous shoots of the current year were examined without finding larvæ. On the 12th June, some 50 young toon were examined and found immune ; these trees were re-examined on the 20th June, 1914 and incipient attacks discovered.



EMERGENCE OF MOTHS OF 1st AND 2nd GENERATIONS, 1916.

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Available data, therefore, point to the fact that it is only in vigorously growing trees, which produce both succulent leafy shoots and fertile fruits, that all five generations of the borer can successively exist.

3. THE THIRD GENERATION.

Larvae of the Third Generation.

1914. In 1914. the field-work carried out during July gave indications of broods of the pest attacking the growing shoots put out by young trees at the break of the rains, but gave no further indication beyond the fact that larvæ of this generation occur throughout the month.

1915. *Field-work.*—In June 1915, field-work was commenced at an earlier date and extended to the examination of fruits as well as of shoots for signs of the existence of the third generation. Fruits collected between the 17th and 29th June showed less than 2 per cent. of attack ; at this period of the year the majority of the fruits are mature and the epidermis has become too suberised to permit of penetration by the younger larvæ. The appearance of new shoots towards the end of May and in June, moreover, provides an alternate supply of soft green plant tissue which is evidently more attractive to egg-laden females and more suitable for the early development of the first stage larvæ. Examination of new shoots revealed larvæ at work as early as the 3rd June. First stage larvæ were found inside toon shoots on the 8th June ; first and second stage larvæ were observed on the 18th June ; eggs, first, second and third stage larvæ were found on the 26th June ; shoots collected between the 30th June and the 7th July contained larvæ of all stages. and a few eggs were also seen on the leaves. Shoots collected on the 29th July and later contained generally pupæ or mature fourth stage (bluish-green) larvæ.

It was thus established that larvæ of this generation normally occur feeding inside the shoots throughout the months of June and July.

Insectary Work.—Simultaneously with the field-work, experiments were carried out in the insectary to determine the absolute length of the larval period and of the stages of the life-cycle.

1. In one of the large outdoor wire-gauze cages of the insectary a sapling toon had been planted in the previous year, and on the appearance of new shoots breeding experiments were commenced. In the absence of eggs, very young first stage larvæ obtained from field-collections were inoculated each on a separate shoot. The larvæ began immediately to feed and bore into the soft epidermis. Within five minutes of deposit on the plant, the head of the larvæ was almost

concealed within the superficial tissue ; the insect continued to bore in at this rate until it disappeared in a gallery extending towards the centre of the shoot, or in an irregular depression partially covered with excreta and fragments of plant tissue.

The inoculated shoots were examined on alternate days, and the changes in the development of the larvæ recorded. In order to observe exactly when moults occurred, and to measure the corresponding length of the larval instar the shoots were split slightly or pared above the site of the gallery. After the necessary observations had been completed, the split portion of the shoot was repaired with tape. This procedure undoubtedly disturbed the larva while the observations were being made, but they were carried out rapidly, as a glance at the body color and the size of the head was sufficient to determine if a change had occurred or was imminent. The length of the life-cycle was not appreciably affected, as under natural conditions the larva often leaves the interior of a shoot in which it is feeding, to eat the external layers or to bore in at a new spot.

When the larvæ had pupated, the shoots were cut off and transferred to rearing cages, in order to record the emergence of the moth.

2. An experiment on parallel lines was carried out in glass rearing-cages containing moist earth, for the reception of inoculated shoots. When the necessity occurred, the larvæ were transferred to fresh shoots.

The result of the inoculation experiments are shown in tabular form on the next page.

TABLE 21.—*Length of the Larval Stages of the Third Generation, 1915.*

STAGE.	INDIVIDUAL No. 1.		INDIVIDUAL No. 2.		INDIVIDUAL No. 3.		INDIVIDUAL No. 4		INDIVIDUAL No. 5.		INDIVIDUAL No. 6.	
	INOCULTED 8TH JUNE.		INOCULATED 8TH JUNE.		INOCULATED 5TH JUNE.		INOCULATED 5TH JUNE.		INOCULATED 12TH JUNE.		INOCULATED 12TH JUNE.	
	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days	Date of Moult.	No. of Days.
First . .	..	8	..	7	..	9	..	8	..	8	..	9
Second . .	June—16th	7	June—15th	9	June—14th	10	June—13th	..	June—20th .	9	21st June	10
Third . .	23rd	14	24th	14	24th	16	Died	..	29th .	15	1st July	16
Fourth . .	July—7th .	22	July—8th	23	10th	21	..	..	14th July	24	17th .	23
Pupal . .	29th .	14	31st	14	August—1st	14	..	..	August—7th .	14	August—9th .	13
Moth	12th Aug.	..	14th Aug	..	15th	..	..	..	21st .	..	22nd .	..

The life-cycles of individuals 1-4 were carried through on a sapling in the out-door cage, and of 5 and 6 in glass jars in moist earth. Individual No. 4 moulted to the second stage on the 13th June, but was injured by the scalpel when dissecting the shoot, and subsequently died.

The length of the feeding period of the larva of the third generation may be summarized from the following complete cycles :—

Date of Inoculation.	Date of Pupation.	Number of days in Larval period.
June—		
5th	1st August	56
	July—	
8th	29th	51
8th	31st	53
12th	6th August— . . .	56
12th	7th ,, . . .	58

3. As a further check on insectary results, one of the toon trees in the Research Institute Grounds was kept under special observation and affected shoots collected at regular intervals. Shoots collected on the 3rd June contained mostly early first stage larvæ, which continued in abundance up to about the 10th June. On the 11th of the month second stage larvæ made their appearance, together with a proportion of first stage individuals. Both stages were observed up till the 19th June. Third stage larvæ were obtained on the 20th, and shoots collected from this date onwards until the 4th July were found to contain the first three stages of the *robusta* larva. On the 5th July the bluish-green larvæ of the fourth stage were first observed, and continued regularly to be obtained until the 27th July. On the 28th July the first specimens of pupæ were encountered; these individuals emerged as moths on the 12th August.

From the evidence provided by this tree, we are justified in assuming that the lengths of the larval stages and the total length of the feeding period as obtained under insectary conditions represent, with sufficient accuracy, the normal development in the field.

The results obtained of the experiments detailed above may be summarized, as far as the development is concerned, as follows :—

Average number of days of the—

First stadium	= 8·2
Second ,, ...	= 9·0
Third ,, ...	= 15·0
Fourth ,, ...	= 22·8

The feeding period (as reckoned from the date of inoculation to the date of pupation) shows :—

Minimum length in days	=51
Average .. ,, ...	=55
Maximum ,, ,, ...	=58

The larva requires 24-48 hours for the construction of the cocoon preparatory to pupation, and takes no food during this period. The actual feeding period is, therefore, approximately 53-54 days.

Pupae of the Third Generation.

1914. No observations were made during 1914 on the length of the pupal stage of the third generation, but pupæ were collected at the end of July from which moths were bred out.

1915. Pupæ were obtained in the field in July 1915, mainly after the 28th July. In the insectary pupæ were available in July and August from specially bred larvæ. The following table shows the length of the pupal period in the case of 5 individuals.

TABLE 22.—*Length of the Pupal Stage of the Third Generation, 1915.*

Individual Serial Number.	Date of Pupation.	Date of Emergence.	Number of Days in Pupal Period.
	July—	August—	
1	29th . .	12th . .	14
2	31st . .	14th . .	14
	August		
3	1st . .	15th . .	14
4	6th . .	20th . .	14
5	7th . .	20th . .	13

The shortest pupal period recorded is of 13 days and the longest 14 days, with a mean of 13·6 days and a mode of 14 days. The earliest date of pupation recorded is on the 12th July and the latest on the 12th September. The majority of pupations occurred between the 29th July and the 27th August.

Moths of the Third Generation.

1914. From material (infested shoots) collected in July 1914 the following emergences were obtained :—

TABLE 23.—*Emergence of the Moths of the Third Generation, 1914.*

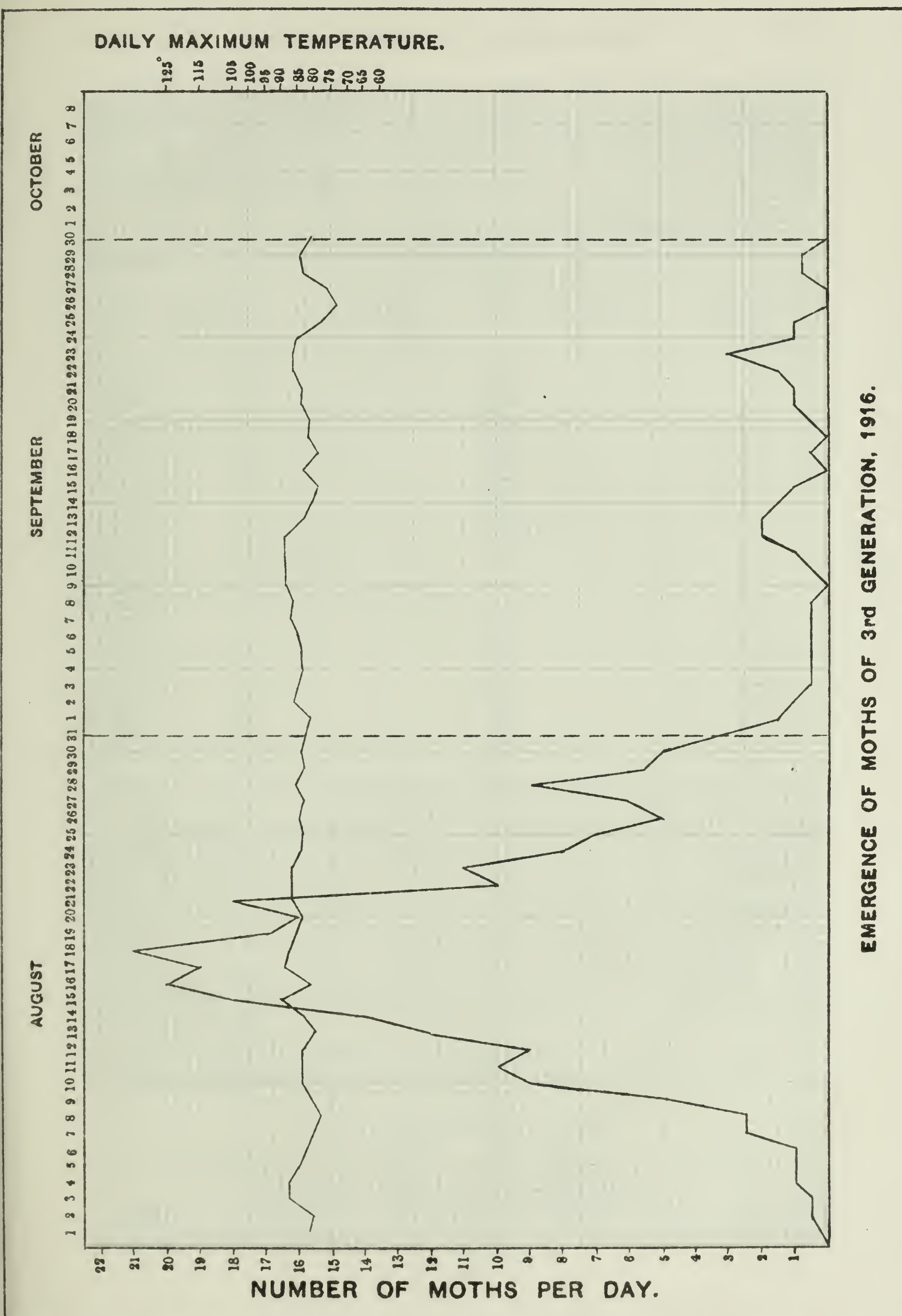
Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
August—		August—	
3rd . . .	1	9th . . .	7
4th	2	10th . . .	4
5th	4	11th . . .	5
6th	5	12th . . .	3
7th	3	17th . . .	1
8th	6		

1915. Material was again collected in July and August 1915 to determine the emergence period of the moth of this generation. It may be noted here that the difficulty of locating sapling toon in abundance, and of obtaining a large supply of infested shoots accounts for the relatively small number of emergence records for this generation as compared with those of the two preceding generations.

TABLE 24.—*Emergence of Moths of the Third Generation, 1915.*

Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
26th July . . .	1	August—	
August—		30th . . .	2
2nd . . .	1	31st . . .	4
11th . . .	3	September—	
12th . . .	4	1st . . .	2
14th . . .	3	3rd . . .	3
16th . . .	2	8th . . .	3
19th . . .	3	9th . . .	3
20th . . .	5	10th . . .	2
21st . . .	4	12th . . .	2
22nd . . .	3	14th . . .	2
24th . . .	4	15th . . .	1
25th . . .	3	17th . . .	1
27th . . .	3	21st . . .	1
29th . . .	2	26th . . .	1

The earliest observed emergence occurred on the 26th July and the latest on the 26th September ; the majority of moths emerged between the 11th and the 31st August.



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1916. Throughout the months of June, July and August, toon shoots attacked by *robusta* larvæ were collected in various localities in the Dehra Dun District, and kept in glass rearing cages in the insectary. The emergence of moths is tabulated below :—

TABLE 25.—*Emergence of Moths of the Third Generation, 1916.*

Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
August—		August—	
1st . . .	1	25th . . .	7
4th . . .	2	26th . . .	5
6th . . .	2	27th . . .	6
8th . . .	5	28th . . .	9
9th . . .	4	29th . . .	6
10th . . .	9	30th . . .	4
11th . . .	10	31st . . .	3
12th . . .	8	September—	
13th . . .	12	2nd . . .	2
14th . . .	16	4th . . .	3
15th . . .	18	7th . . .	3
16th . . .	20	11th . . .	3
17th . . .	19	12th . . .	2
18th . . .	21	13th . . .	3
19th . . .	17	14th . . .	4
20th . . .	16	18th . . .	3
21st . . .	18	22nd . . .	2
22nd . . .	10	23rd . . .	5
23rd . . .	11	28th . . .	1
24th . . .	8	29th . . .	1

The earliest moths appeared in the rearing cages on the 1st August and the latest on the 29th September, with a general maximum emergence between the 8th and the 31st August. These results agree generally with those obtained on a smaller scale in 1915, but it is probable that some of the moths which appeared in the breeding cages late in September may represent early broods of the fourth generation. It is not possible to differentiate material obtained in the field during the critical period.

In Plate VIII the emergence of the 1916 moths is shown in a curve constructed from the progressive daily totals.

4. THE FOURTH GENERATION.

Larvae of the Fourth Generation.

1915. *The field-work* carried out in August and September gave some indication of the boundaries between the 3rd and 4th generations which had previously not been recognised as separate periods. Eggs were not found on the leaves of the shoots collected daily, until the 4th September, but previously (particularly between the 14th and 21st August) the occurrence of first stage larvæ showed that the generation had already commenced. Shoots examined between the 8th and 16th of September revealed first, second, and third stage *robusta* larvæ, and many shoots containing no larvæ showed signs of recently abandoned borings and feeding patches. From the 18th to the 27th September, third and fourth stage larvæ were more numerous, but eggs were again obtained on leaves as late as the 28th September. From this date onwards to the 8th October, pupating larvæ and pupæ were abundant. On the 12th October, a moth was obtained in the act of emerging from a shoot. Similar records obtained in 1916 show that all the stages of the 4th generation of the borer may be found during the months August, September and October.

Insectary work 1.—As with the larvæ of the 3rd generation, inoculation experiments were carried out in the insectary cages to determine the feeding period of fourth generation larvæ. The method of inoculation and observation was the same in both cases. (*vide* pp. 45—46.) The results are given in table 26 on the next page.

TABLE 26.—*Length of the Larval Stages of the Fourth Generation, 1915, Series 1.*

STAGE.	INDIVIDUAL No. 1.		INDIVIDUAL No. 2.		INDIVIDUAL No. 3.		INDIVIDUAL No. 4.		INDIVIDUAL No. 5.		INDIVIDUAL No. 6.	
	INOCULATED 9TH AUGUST.		INOCULATED 9TH AUGUST.		INOCULATED 15TH AUGUST.		INOCULATED 15TH AUGUST.		INOCULATED 29TH AUGUST.		INOCULATED 29TH AUGUST.	
	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.
First . .	..	8	..	9	..	10	..	11	..	10	..	6
Second . .	August—17th .	11	August—18th .	8	August—24th .	9	26th Aug.	9	September 8th .	8	Sept.—4th .	8
Third . .	28th .	13	26th .	14	Sept.—2nd .	14	Sept.—4th .	14	16th .	13	12th .	13
Fourth . .	Sept.—10th .	20	Sept.—9th .	21	16th .	23	18th .	22	29th .	21	28th .	21
Pupal . .	30th .	13	20th .	14	October—8th .	13	October—10th .	13	20th Oct.	13	October—17th .	13
Moth . .	13th Oct.	..	14th Oct.	..	21st .	..	23rd .	..	2nd Nov.	..	30th .	..

2. Coincident with the observations made on larvæ in the trees growing in the outdoor cages, similar experiments were conducted with larvæ in cut shoots of toon kept under moist conditions in glass jars indoors. The records of three individuals are given below :—

TABLE 27.—*Length of the Larval Stages of the Fourth Generation 1915, Series 2.*

STAGE.	INDIVIDUAL No. 7. Inoculated 10th August. Date of Moult.	No. of Days.	INDIVIDUAL No. 8. Inoculated 10th August. Date of Moult.	No. of Days.	INDIVIDUAL No 9. Inoculated 10th August. Date of Moult.	No. of Days.
First	..	9	..	8	..	9
	August—		August—		August—	
Second . . .	19th .	8	18th .	8	19th .	8
Third . . .	27th .	14	26th .	15	27th .	15
Fourth . . .	10th Sept.	21	10th Sept.	21	11th Sept.	21
	October—		October—		October—	
Pupal . . .	1st .	14	1st .	13	2nd .	14
Moth . . .	15th .	..	14th .	..	16th .	..

The lengths of the stages of the fourth stage larvæ may be summarized from the above records :—

Average number of days of the—

First Stadium	= 8·9
Second „	= 8·6
Third „	=14·0
Fourth „	=21·2

The following statement summarizes the lengths of the larval period recorded in the above experiments.

Table 28.—*Length of the Larval Period of the 4th Generation, 1915.*

Individual No.	Date of Inoculation.	Date of Pupation.	Total No. of Days.
	August—	September—	
1	9th . .	30th . .	52
2	9th . .	30th . .	52
		October—	
3	15th . .	8th . .	54
4	15th . .	10th . .	56
5	29th . .	20th . .	52
6	29th . .	17th . .	49*
	September—	November—	
7	10th . .	1st . .	52
8	10th . .	1st . .	52
9	10th . .	2nd . .	53

		days.
Minimum length of larval period	. . . . . .	=49
Average ,, ,, ,,	. . . . . .	=52·4
Maximum ,, ,, ,,	. . . . . .	=56

Allowing one or two days for the construction of the cocoon during which period the larva takes no food, it will be seen that average length of the feeding period in this generation is about 51 days. This is two or three days shorter than the feeding period of the 3rd generation, a fact probably due to the slight local rises in temperature which occur after the first month of rains.

Pupae of the Fourth Generation.

1913. The length of the pupal period was determined from a few observations in October 1913 to be 13 days.

1915. The rearing experiments previously detailed, yield data on the length and dates of the pupal period (*vide* Tables 26, 27). Summarized, the data show that :—

The length of the pupal period is 13 days in 6 cases.

,, ,, ,, ,, ,, ,, 14 ,, ,, 3 ,,

The mean is 13·3, and the mode 13 days.

The earliest recorded date of pupation is 28th September and the latest date is the 8th October.

* The short period for individual No. 6 is due to the fact that it was already 4 days older than No. 5 on the date of inoculation

Moths of the Fourth Generation.

1915. The emergence records of the fourth brood moths in 1915 are not numerous, as extensive collection of material could not be carried on throughout the season ; the extreme dates given in Table below do not therefore represent the extremes of the moth emergence period.

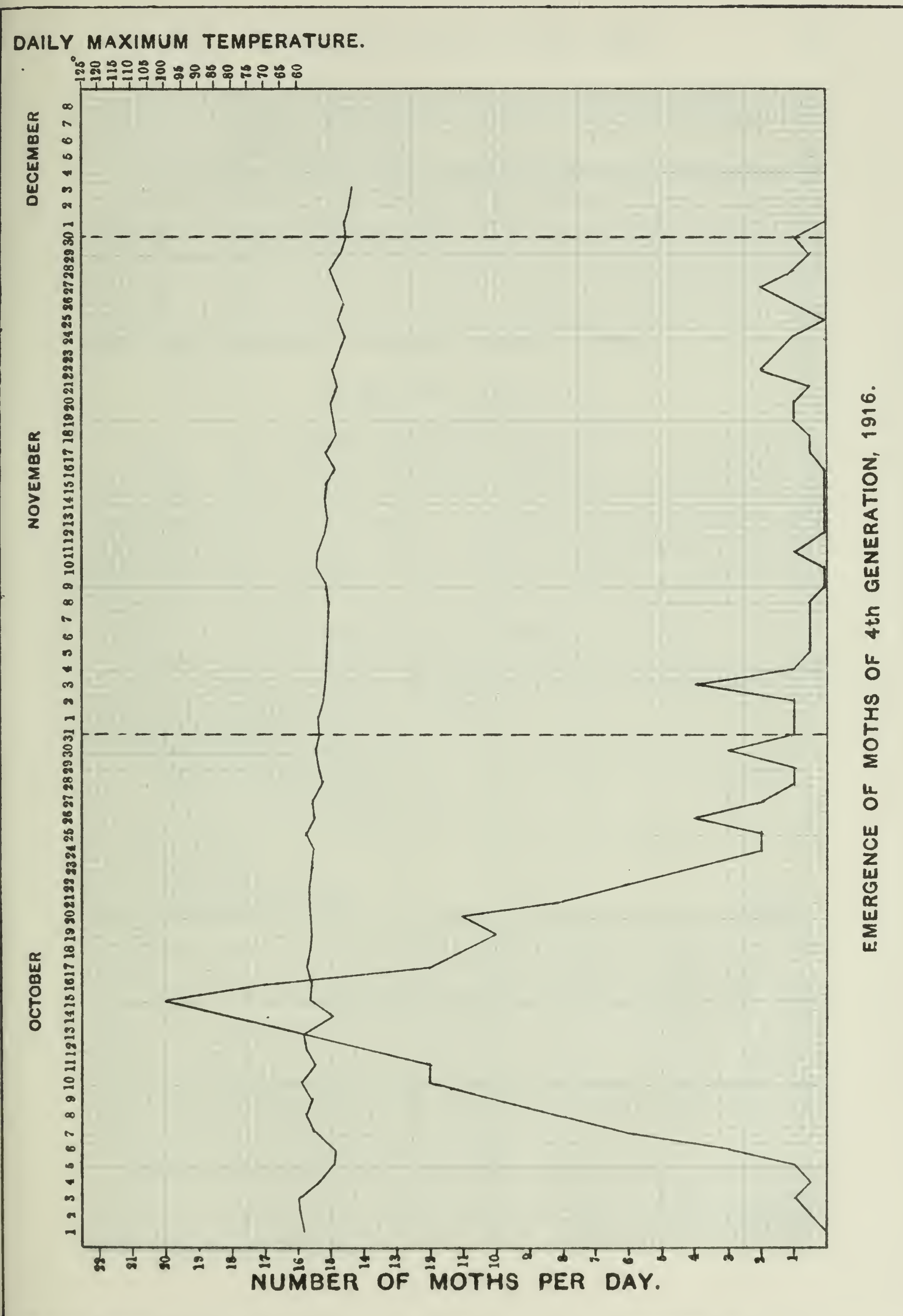
TABLE 29.—*Emergence of Moths of the Fourth Generation, 1915.*

Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
October—		October—	
2nd . . .	1	17th . . .	2
5th . . .	2	18th . . .	2
6th . . .	2	21st . . .	2
7th . . .	2	23rd . . .	2
10th . . .	3	24th . . .	1
11th . . .	3	25th . . .	1
12th . . .	2	28th . . .	1
13th . . .	3	30th . . .	1
		November—	
14th . . .	5	1st . . .	1
15th . . .	6	2nd . . .	1
16th . . .	7	13th . . .	1

1916. During the months of August, September and October, attention was mainly directed to obtaining material for emergence records of the fourth brood moths. The figures are given in Table 30 below, and the curve constructed from these data is shown in Plate IX.

TABLE 30.—*Emergence of Moths of the Fourth Generation, 1916.*

Date of Emergence.	Number of Moths.	Date of Emergence.	Number of Moths.
October—		October—	
2nd . . .	1	24th . . .	2
3rd . . .	1	25th . . .	1
5th . . .	1	26th . . .	4
6th . . .	3	27th . . .	2
7th . . .	6	28th . . .	1
8th . . .	8	29th . . .	1
9th . . .	10	30th . . .	3
10th . . .	12	31st . . .	1
		November—	
11th . . .	12	1st . . .	1
12th . . .	14	2nd . . .	1
13th . . .	16	3rd . . .	4
14th . . .	18	4th . . .	1
15th . . .	20	6th . . .	1
16th . . .	17	8th . . .	1
17th . . .	12	11th . . .	1
18th . . .	11	20th . . .	3
19th . . .	10	22nd . . .	1
20th . . .	11	23rd . . .	2
21st . . .	8	24th . . .	1
22nd . . .	6	27th . . .	3
23rd . . .	7	30th . . .	1



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The earliest moth emerged on the 2nd October and the latest on the 30th November. The period of maximum emergence occurs within the first four weeks of October.

A comparision of the emergence periods of the 3rd and 4th generation moths (*vide* Tables 24, 25 and 29, 30 and Plates VIII and IX) shows that the two broods slightly overlap. The latest recorded emergence of a third brood moth is on the 29th September, and the earliest emergence of a fourth brood moth is on the 2nd October. In view of the small number of individuals used in the experiments, it is evident that under field conditions overlapping normally occurs.

5. THE FIFTH GENERATION.

Larvae of the Fifth Generation.

1913. When attention was first devoted to the life-history of *Hypsipyla robusta* in 1913, it was with the assumption that two or at most three generations occurred in the year. The preliminary work, while indicating that the existing accounts of the life-history of the pest were incorrect in this respect, was of little value as a record of the distribution of broods. Some of the later field data bear on the larval broods of the fifth generation and are therefore recorded.

Field-work.—On the 20th December 1913, 34 toon shoots on young trees in the Sylviculturist's Experimental Garden, Dehra Dun, were examined with the following results :—

Shoots with healthy larvæ = 25—	
One year old shoots, green	12 larvæ.
,, ,, ,, ,, dry	8 ,,
Two year old shoots, green	3 ,,
,, ,, ,, ,, dry	2 ,,
Shoots with—	
Dead or diseased larvæ	7 ,,
Pupæ, 1 living, 1 empty	2 pupæ.
No insects	2 blanks.

Insectary work.—About 70 shoots containing larvæ (collected October-December 1913) were kept under various conditions in the Insectary. It was found that unless special precautions were taken, the cut shoots desiccated sufficiently to cause the death of the hibernating larva inside. The majority of larvæ died at the end of December and early January, a few only survived until the 3rd week in January. The shoots kept under moist conditions, *i.e.*, in tubes or porous pots, gave successful results and moths were obtained in March 1914.

1914.—*Field work.* The general stage of the fifth broodlarvæ in the field was determined by collections at intervals in February, March and April of infested shoots from selected localities in the Sylviculturist's Experimental Garden.

TABLE 31.—*Stages of the Fifth Generation in the Field, 1914.*

Date of Observation.	No. of trees examined.	CONTENTS OF INFESTED SHOOTS.					TOTALS.
		Live larvæ.	Dead larvæ.	Parasitised larvæ.	Live pupæ.	Empty Pupæ.	
27th February . . .	29	35	7	7	1	6	55
4th March	38	9	3	6	10	3	31
17th ,, ...	30	2	..	3	9	1	15
3rd and 4th April . .	53	1	2	3	11	10	27
24th and 25th April . .	74	..	15	..	2	36	53

From the observations recorded, it is concluded that, (1) at the end of February the general stage of the generation is that of the mature hibernating larva ; a few early individuals have emerged as moths (one was observed emerging on the 27th February) ; (2) a week later, pupæ are met with as numerously as larvæ ; (3) on the 17th March the general stage is that of the pupa, with a few late larvæ ; (4) early in April, pupæ and moths are equally numerous, and (5) in the third week of April, the general stage is that of the moth.

At the latter end of 1914 field collection was carried out regularly, but the greater part of the material gave negative results. Many of the larvæ taken in November and December were found to be dead, killed apparently by cold, and the remainder were either parasitized or attacked by a mummifying fungus.

1915. The field collection was continued in January and February under the same adverse conditions. Out of a total of 400 shoots collected, 300 were found to contain dead larvæ and of the remainder a large number died as a result of desiccation.* The moth emergence dates from this material are given in Table 2.

Throughout October, November and December 1915, toon shoots were collected for laboratory examination. From the 6th October up to the 10th November eggs, first, second, third and fourth stage larvæ of the fifth or overwintering broods were obtained. After the 10th November, all the shoots collected contained bluish-green larvæ of the fourth stage.

1916. The shoots brought in by collectors during January, March, if infested, contained hibernating larvæ of the fourth stage in chamber closed by a partition of silk.

Insectary work.—The development of the fifth brood of larvæ was determined by inoculation experiments analogous to those carried out for the 3rd and 4th generations. The results are given in Table 32.

* NOTE.—At this period the offices of the Forest Zoologist were transferred from the old quarters to the New Research Institute building and many experiments in progress had to be abandoned.

TABLE 32.—*Length of the Larval Stages of the Fifth Generation, 1915-1916.*

STAGE.	INDIVIDUAL No. 1. Inoculated 12th October.		INDIVIDUAL No. 2. Inoculated 12th October.		INDIVIDUAL No. 3. Inoculated 19th October.		INDIVIDUAL No. 4. Inoculated 19th October.		INDIVIDUAL No. 5. Inoculated 20th September.		INDIVIDUAL No. 6. Inoculated 26th September.	
	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.	Date of Moult.	No. of Days.
First .	..	7	..	5+	..	6	..	4+	..	2	..	..
	Oct.—		Oct.—									
Second .	19th .	9	17th .	8	25th Oct. .	9	23rd Oct. .	9	28th Sept.	9	Died on 3rd Oct.	..
					Nov.—		Nov.—		Oct.—			
Third .	28th .	14	25th .	14	3rd .	14	1st .	14	7th .	15		
Fourth .	11th Nov.	104	8th Nov. .	103	17th .	101	15th .	101	22nd .	117		
Pupal .	23rd Feb. .	15	19th Feb. .	14	26th Feb. .	14	24th Feb. .	13	16th Feb. .	13		
Moth .	9th Mar. .	..	4th Mar. .	..	11th Mar. .	..	8th Mar. .	..	29th Feb. .	..		

The lengths of the larval stages summarized from the data above are :—

Average number of days in the first stadium . . .	= 4·8	*Plus.*
,, ,, ,, ,, second stadium . .	= 8·8	
,, ,, ,, ,, third stadium . . .	= 14·2	
,, ,, ,, ,, fourth stadium . . .	= 105·2	

The absolute length of the first larval stadium is not determinable since the individuals used were several days old on the date of inoculation.

The following statement shows the lengths of the larval periods in 5 cases.

Table 33.—*Length of the Larval Period of the 5th Generation, 1915-1916.*

Individual Number.	Date of		Total number of days.
	Inoculation.	Pupation.	
	October—	February—	
1	12th . .	23rd . .	134
2	12th . .	19th . .	130
3	19th . .	26th . .	130+
4	19th . .	24th . .	128+
5	26th . .	16th . .	143+

With a deduction of 1—2 days spent in constructing the cocoon it is estimated that the average larval period (feeding *plus* hibernation) occupies 132 days. The absolute feeding period has not been determined ; it is presumably somewhat longer than that of the 4th generation.

Pupae of the Fifth Generation.

The occurrence of fifth brood pupæ has already been noted in the previous records of the field work carried out on this generation.

1914. The length of the pupal period was determined in 1913-14 from the following observations :—

Table 34.—*Length of the Pupal Period of the 5th Generation, 1913-1914.*

Individual Number.	Date of Collection of shoots.	Date of Pupation.	Date of Emergence.	Total number of days.
	Dec. 1913—	March 1914—	March 1915—	
1	20th . .	5th . .	19th . .	14
2	20th . .	5th . .	22nd March 1914	17
3	22nd . .	12th . .	24th ,, ,,	12
4	22nd . .	24th . .	6th April ,,	12
5	27th February 1914.	28th February	28th February ,,	14
6	4th March 1914	7th March .	22nd March ,,	15

1915. The conditions under which the experiments recorded above were carried out were not considered satisfactory, and a repetition was attempted in the following season, but conditions were again adverse and negative results were obtained.

1916. In this year records for the pupal stage of the 5th generation were obtained from inoculation experiments, see following Table 35.

TABLE 35.—*Length of the Pupal Period of the 5th Generation, 1915-1916.*

Individual number.	Date of collection of shoots.	Date of Pupation.	Date of Emergence.	Total number of days.
	Ocober 1915—	February 1916—	March 1916—	
1	12th . .	23rd . .	9th . .	15
2	12th . .	19th . .	4th . .	14
3	19th . .	26th . .	11th . .	14
4	19th . .	24th . .	8th . .	13
5	26th September	16th . .	29th February	13

	Days.
The shortest length of the Pupal Period is	13
The average length of the Pupal Period is	13·8
The longest length of the Pupal Period is	15

The earliest recorded date of pupation is the 16th February and the latest date the 24th March.

Moths of the Fifth Generation.

The emergence of the moths of the fifth or spring brood has already been recorded at the commencement of the life-history studies.

See pp. 20, Table 2, Plate V. The earliest record is the 18th February and the latest the 12th April, with the optimum period of emergence from the 2nd week in March to the 4th week in March.

The annual life-cycle is thus completed with emergence of the moths of the fifth generation. A summary of the seasonal history will be found on pp. 64—65 and a graphic representation in Plate X.

Variation in development and over-wintering of Larvæ.

It will be observed that throughout the seasonal history studies remarkably few cases of delayed or abnormal development were encountered. A comparison of the records in this paper with those obtained in studies of the seasonal history of the codling moth in the Pecos Valley, New Mexico, [Quaintance and Geyer, 1917] is of interest as the habits of the two insects are not very dissimilar. The investigators in New Mexico found that the codling moth produces three complete generations and a partial fourth in that locality, as against 1 complete and 1 incomplete generation in the northern states ; and that larvæ of all broods may overwinter without transforming. In one of the years under observation, 7·16 per cent. of the first brood larvæ, 19·98 per cent. of the second brood, 75·06 per cent. of the third brood and 100 per cent. of the fourth brood passed through the winter.

In our breeding cages there were no observed cases of abnormally delayed development and no indications of a tendency on the part of early brood larvæ to overwinter. It is, however, not improbable that late fourth brood larvæ hibernate and do not transform until the following spring. The percentage cannot be high since it is not conspicuous.

2. Seasonal History in the Punjab.

The observations made by B. O. Coventry in Changa Manga plantation, Lahore Division, in 1898 led him to conclude that two generations of *Hypsipyla robusta* occurred in that locality, the first feeding on flower and fruits, and the second boring into the shoots. He represented the cycle by the following diagram :—

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1898				- - - -	- - ●*	****	**** ..	- - - -	- - - -	●●**	****	****
1899	****	****	**** ..									

* = imago or moth. ⁎ = imago and egg stage.

- = larval stage. ● = pupal stage.

——— = denotes period during which Insect is destructive.

" The egg stage and duration of the imago stage in the second generation is doubtful."

No connected seasonal history studies have been carried out in the Punjab ; but if isolated records are pieced together, it will be seen that the inference of a 5-generation cycle similar to that occurring at Dehra Dun is justified.

Coventry, *loc cit*, p. 368, noted that larvæ occurred feeding on fruits and flowers on April 24th. " By May 1st the larvæ were more or less fully grown and were to be found in swarms, on the trunks of the trees. ....The trunks of the trees were covered with a dense mass of silken threads," Pupation was noted on the 29th April ; moths were obtained on May 6th, and by May 15th all pupæ collected had produced moths. The pupal stage was found to last for one week or ten days.

It is evident that these observations refer to the 2nd generation.

1916. In April 1916 a number of toon trees were sack-banded at the Zoologist's request by the Range Officer, Changa Manga, and the cocoons obtained in the bands mailed to Dehra Dun in two consignments, RRD. 126 arriving on the 4th May, and RRD. 135 arriving on the 15th May. The emergence records of the moths from these cocoons is given in Table 36 below :—

TABLE 36.—*Emergence of Moths of the 2nd Generation, Changa Manga, 1916.*

Date of Emergence.	Number of Moths.		Date of Emergence.	Number of Moths.	
	Batch 126.	Batch 135.		Batch 126.	Batch 135.
May—			May—		
4th . .	10	Emergences commenced *en route.*	19th . .	..	10
5th . .	22		20th . .	1	9
6th . .	32		21st . .	..	13
7th . .	16		22nd .	1	10
8th . .	25		23rd . .	3	3
9th . .	62		24th . .	..	5
10th . .	18		25th . .	..	3
11th . .	1		26th . .	..	10
12th . .	1		27th . .	..	7
13th . .	2		28th . .	..	15
14th . .	..		29th .	..	..
15th . .	7		30th . .	..	3
16th . .	8	30	31st . .	..	..
			June—		
17th . .	1	10	1st . .	..	..
18th . .	2	21	2nd . .	..	..

The above quoted data merely show that 2nd brood moths emerge in the Punjab throughout the month of May, as they do in Dehra Dun ; they do not show the limits of the brood-period or the dates of maximum abundance.

Coventry noted the presence of larvæ boring in shoots during August and September ; these represent the third brood larvæ.

Early in October 1912, shoots containing *robusta* larvæ were collected by the Divisional Forest Officer, Kangra, in Cheli Nerwana forest. These yielded moths in the fourth week of October representing the existence of the fourth brood. A moth in the collection of the Agricultural Research Institute, Pusa, bred in November 1914 from a larvæ collected at Taru, Peshawar, in the previous month is also of this brood.

There is, therefore, at least a partial fifth generation in the Punjab.

Summary of the Seasonal History Studies.

The first or flower generation.—The earliest recorded emergence of spring brood moths is the 18th February. The first generation may, therefore, commence in the fourth week of February. The average development is :—

	Days.
Incubation period of egg	4—5
Period of first larval stage	4
,, second larval stage	2
,, third larval stage	2
,, fourth larval stage	4
,, pupal stage	8—12
TOTAL CYCLE, EGG TO MOTH	24—29

Theoretically, the earliest eggs of this brood should produce moths in the field in the third or fourth week of March, but the earliest insectary records for 2nd brood moths is the 8th April.

The limits of the generation lie within a period of 8 to 9 weeks.

The second or fruit generation.—The theoretical dates for the appearance of moths from eggs laid in the fourth week of March is in the third or fourth week of April; the earliest insectary record is the 1st May. The average development is :—

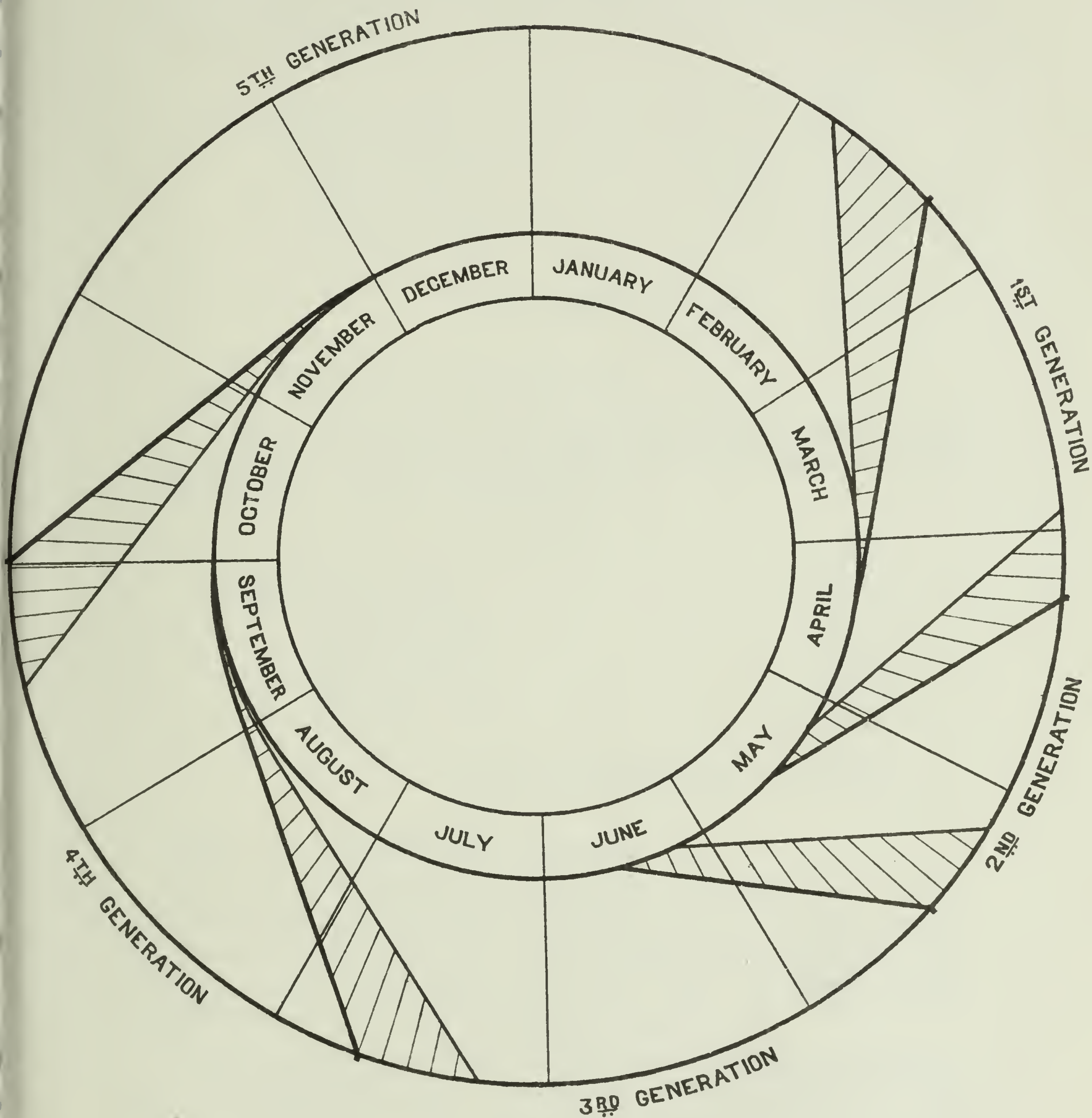
	Days.
Incubation period of egg	4—5
Period of first larval stage	4
,, second larval stage	2
,, third larval stage	2
,, fourth larval stage	4
,, pupal stage	8—12
TOTAL CYCLE, EGG TO MOTH	24—29

The limits of the generation lie with a period of 9 to 10 weeks.

The third or shoot generation.—The theoretical date for moths of the third generation is in the second week of July. The average development is :—

	Days.
Incubation period of egg	4—5
Period of first larval stage	7—9
,, second larval stage	7—10
,, third larval stage	14—16
,, fourth larval stage	21—24
,, pupal stage	13—14
TOTAL CYCLE, EGG TO MOTH	66—78

THE SEASONAL HISTORY OF THE TOON SHOOT AND FRUIT BORER.



The annual succession of broods of *Hypsipyla robusta*, Moore, is shown in diagrammatic form. The points on the circumference of the outer circle indicate the *earliest* dates at which the broods may normally occur, and the connected points on the circumference of the inner circle indicate the *latest* dates on which the same broods may occur. The solid black lines represent the moth period, the hatched zone, the pupal period and the blank zone, the larval period. A reading taken along any one radius will reveal what stages of the borer are likely to occur on any one date.

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Limits of the generation within 17 to 19 weeks.

The fourth generation.—The theoretical date for fourth brood moths is in the fourth week of September; recorded date is the 2nd October. Average development :—

	Days
Incubation period of egg	4— 5
Period of first larval stage	5— 1
,, second larval stage	8—21
,, third larval stage	13—15
,, fourth larval stage	20—23
,, pupal stage	13—14
TOTAL CYCLE, EGG TO MOTH .	64—79

Limits of the generation 17 to 19 weeks.

The fifth or overwintering generation.—The theoretical date for fifth brood moths is in the third week of February; the recorded date is the 18th February. Average development :—

	Days.
Incubation period of egg	4— 5
Period of first larval stage	7— 9
,, second larval stage	8— 9
,, third larval stage	14—15
,, fourth larval stage	101—117
,, pupal stage	13—15
TOTAL CYCLE, EGG TO MOTH .	147—170

Limits of the generation 28 to 31 weeks.

The disparities between the theoretical and actual dates for the commencement of the successive generations are very small, and probably to be accounted for by the fact that inside the insectary the maximum daily temperatures are lower, and the total effective temperature is obtained by the insect at a slower rate.

In the accompanying Plate X, the annual succession of broods is shown in diagrammatic form. The points on the circumference of the outer circle indicate the earliest dates on which the stages normally occur in the year; the connected points on the circumference of the inner circle indicate the latest dates on which the corresponding stages may occur. A reading taken along any one radius will reveal what stages of the borer are likely to occur on any one date.

Economic Importance.

The economic importance of the pest may be considered from two standpoints: (*a*) injury to the seed-crop, and (*b*) injury to the growth of the tree.

(*a*) *Injury to the seed-crop.*—The consumption of the flowers and fruits by the first two generations amounts, in bad years, to a complete destruction of the seed-crop. Past records from the Punjab and Bengal indicate that difficulty is occasionally met with in collecting sufficient sound toon trees for sowings. In Australia heavy seed-crops of *Cedrela australis* have been almost completely ruined by a borer, which is beyond doubt *Hypsipyla robusta* (Queensland Forestry Bulletin, No. Pt. I, 1917, p. 14).

(*b*) *Injury to the Growth of the Tree.*—This type of injury, being more obvious than the first, has been more frequently recorded in literature and departmental reports. (See Previous History of the Pest).

The combined work of the third, fourth, and fifth generations on young toon trees completely nullifies the season's growth ; not only are the main leaders of the current year killed, but also laterals which have made progress on the woody stems of the previous years. The growth of the sapling appears to be completely checked, but, in the course of time, occasional shoots escape attack and become lignified before the succeeding season and some upward progress is made. In its early stages, the attack of the borer is characterized by a dense bushy growth (See Plates XI, XII), and, in its later stages, by much branched bole and crown, the bifurcation of the main branches always occurring low down on the trunk*. (Plate XIII shows the characteristic branch development of old toon trees in an avenue subject to repeated attacks of the borer).

Numerous records have been obtained in India to show that the establishment of young toon in plantations or in restocking of blanks is impossible in the proximity of old toon trees. The same difficulty arises with mahogany and, as already quoted, in other parts of the world with various species of " Cedar ".

* Incidentally, the presence of the borer may be considered an advantage in avenue production, provided one is prepared to wait long enough.

Photo.-Mechl. Dept., Thomason College, Roorkee.

Young saplings of *Cedrela Toona* showing damage by *Hypsipyla robusta* ; arrows mark the sites of attack by thh 3rd and 4th brood larvæ.

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PART IV.

CONTROL MEASURES.

Several writers have recorded that the pruning and burning of infested shoots on saplings, which it is desired to protect, are without successful results. From the seasonal history studies it is evident that this must be so, since the larvæ so destroyed amount to a very small fraction of the individuals existing on the area in one season.

The following control measures are suggested.

1. PROTECTION OF YOUNG TOON PLANTATIONS.

1. Young plantations with no old or flower-bearing toon trees in the neighbourhood are (theoretically) safe from attack. The simplest method of establishing a plantation lies in the previous removal of all old host-trees in the vicinity.

2. Young plantations with old or flowering toon and other host-trees permanently in the neighbourhood are subject to attack from their second or third year onwards, but may be protected as follows :—

(*a*) At the time of appearance of the flowers, all flower-bearing toon trees should be banded with a strip of sacking, about 12″ wide, and in length sufficient to allow an overlap of 6″. The sack-band should be tied with a cord at breast-height on the trunk and folded double over the binding cord. (See fig. 2).

(*b*) At intervals of not less than 10 days during the flowering and fruiting season, the banded trees should be visited, and all larvæ and cocoons found inside the sack-bands removed and destroyed. (See later, p. 69) When no more larvæ are obtainable, collection should be discontinued.

(*c*) About one month after the fruits are ripe (or collection ceases), the plantation should be traversed and all shoots found to be attacked cut out and burned.

(*d*) If a high degree of attack is found in the plantation, a second pruning should be carried out in the cold weather or three months before the normal flowering date.

2. Protection of toon plantations in the flowering stage.

Plantations which are old enough to bear flowers should be protected by the measures detailed under (*a*) and (*b*) above. Pruning can not be carried out.*

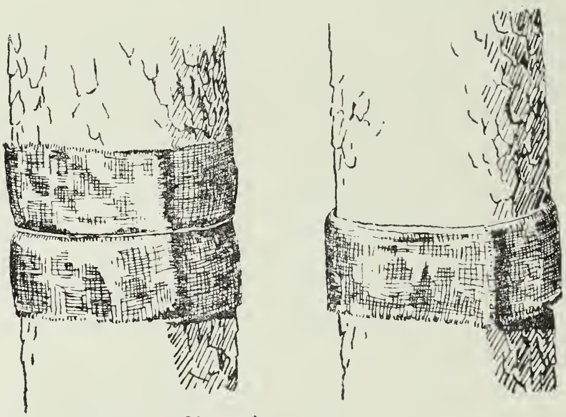
3. Protection of young toon in avenues, tea gardens, etc.

(*a*) It is unprofitable to fill up small blanks in roadside toon avenues, etc., with toon transplants ; other species should be used.

(*b*) Extension of avenues, shade and shelter trees, etc., should be preceded and accompanied by sack-banding of flowering trees as detailed in 1 (*a*), (*b*).

The practical application of control measures.

The method of applying the sack-bands is shown in the figures below ; larvæ spin up between the two layers of sacking and between the sacking and the bark. The removal of large flakes of bark within reach and the cutting away of undergrowth at the base of the tree will add to the value of the bands.



Text figure 2.

Method of applying sack-bands to the trunk.

The number of flowering toon trees that it may be necessary to sack-band in order to protect a plantation, or regeneration area, avenue, etc., obviously depends on the size of the planted area and on the

* The writer appreciates that the measures suggested above are impracticable for the protection of toon plantations surrounded by jungle full of meliaceous host-plants of the borer. They are intended for conditions under which intensive forestry is possible, and toon is grown over large areas as the principal crop. It is not profitable silviculture to attempt small toon plantations of a few acres, or to use that species for stocking blanks and failures on regeneration areas.

Photo.-Mechl. Dept., Thomason College, Roorkee.

A young sapling of *Cedrela Toona* showing bushy growth produced by repeated killing-back of leaders and laterals.

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abundance of toon in the vicinity. The larger and more compact the planted area, the smaller will be the relative number of trees to be banded. The width of the protective zone is roughly estimated at 1,000 to 500 yards, but no experiments have been carried out on the flight of the moths, or the distance travelled by migrating larvæ.

Collection and Destruction of Larvæ.—The number of larvæ varies very much from tree to tree ; not uncommonly, 500 may be found on one tree at one visit. At the period of maximum abundance, a cloth-bag with a draw-string and a tin funnel- shaped mouth-piece will be found useful ; the contents of the bag when full can be emptied into a hole in the ground and buried.

Cost of Sack-Banding and Collection.—The cost of sack-banding and collection of larvæ during the experimental work of 1916 works out at about 2 annas per tree, including the cost of sacking, string, nails, number plates, extra labour, etc. But this represents the cost of the experiment. In control measures where it is not necessary to number the trees with tin plates, count and preserve the larvæ, or make visits so frequently, the cost is probably considerably less than one anna per tree.

Grease-Band Experiments.

As an alternative to the sack-band method of control, the effect of deterrent grease-bands was tested in May 1915. Various preparations of crude oil, tar, etc., were used, but of all the materials only " Tanglefoot " (U. S. A. manufacture) possessed any appreciable effect. The Tanglefoot was applied to the trunks of the trees at breast-height in bands 2″ wide.

Its odour had no deterrent effect either on descending or ascending larvæ or to early—or late—stage individuals. The larvæ on reaching the band were occasionally deflected from their paths, but eventually entered the sticky band and commonly reached the opposite side. Second and third stage larvæ usually failed to pass through the band and died in the grease, but mature larvæ as a rule found no difficulty in passing through the barrage.

On the 14th May, 34 *robusta* larvæ (15 third stage and 19 fourth stage) heavily smeared with Tanglefoot, were collected from grease-banded trees, and confined in rearing cages. The third stage larvæ readily fed on fresh fruits supplied to them, within a few minutes of receipt. On the 16th May, 11 more tangle-footed larvæ were caged. On the 18th May, 26 larvæ were observed to have prepared cocoons and pupated. On the 1st June 1 live, and 18 dead moths were found inside the cage. Thus out of 45 larvæ which had passed through a Tangle-foot band, 31 pupated successfully, and 23 moths, *i.e.*, 50 per cent., emerged successfully. Of the 14 larvæ which died before pupation, 8 were otherwise injured and 6 received no food. In another experiment, a much higher percentage of larvæ died. The net results, however, indicate the low value of Tanglefoot as a deterrent barrier to the larvæ.*

Natural enemies.

The insect is not very extensively preyed upon by natural enemies among the Insecta. Several species of Chalcidoidea, Ichneumonidæ and Braconidæ have been bred from larvæ of all generations, and Carabidæ have been observed to feed on larvæ at sack-bands. The parasites were sent to the Bureau of Entomology, London, together with the diagrams and coloured illustrations prepared, but their determination and description were prevented by the war. When the specialists in those groups are able to resume work, their results will be published in a separate record.

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* Against the Gypsy Moth, Brown tail Moth and Nun Moth larvæ Tanglefoot is a complete deterrent.

Photo.-Mechl. Dept., Thomason College. Roorkee.

An avenue of Toon trees showing characteristic bole and branch development produced by prolonged *Hypsipyla robusta*.

The trees are sack-banded for the collection of swarming larvæ of the first two generations.

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Typical ravine scenery.

Photo.-Mechl. Dept., Thomason College, Roorkee. Photos. by C. E. C. Cox, I. F. S.

The commencement of ravine showing typical erosion.

[Frontispiece

INDIAN FOREST RECORDS

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Afforestation of Ravine Lands in the Etawah District, United Provinces.

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PART I

Introduction.

IN order to appreciate the great possibilities and potential advantages of a wide scheme of afforestation in the plains of the United Provinces, a brief reference to the distribution of the existing forests of the Provinces compared to the population and principal centres of demand is necessary. The area of the Provinces (in round figures) is 100,000 square miles, and the population about 47,000,000. The forest area is 7,000 square miles, or 7 per cent. This in itself by all standards is inadequate, and while the great bulk of the forests are concentrated in the sparsely inhabited hills or submontane tract, the principal cities and manufacturing centres, such as Lucknow, Cawnpore, etc., are far removed from the forest tracts, and the great densely populated Gangetic plain generally is, as regards forest growth, practically naked.

2. The result of this unfortunate but easily understood distribution is apparent in the working of the forests. For the more valuable forest products, large and small timber, bamboos, tanning materials, lac, resin, and other valuable minor products, there is an incessant demand, but for the more bulky and less valuable products, such as fuel, fodder grasses, inferior timbers, small poles and the like, the more inaccessible forest areas are practically untouched. Thus, while in one part of the Province cattle may be dying wholesale for want of food, in many forest

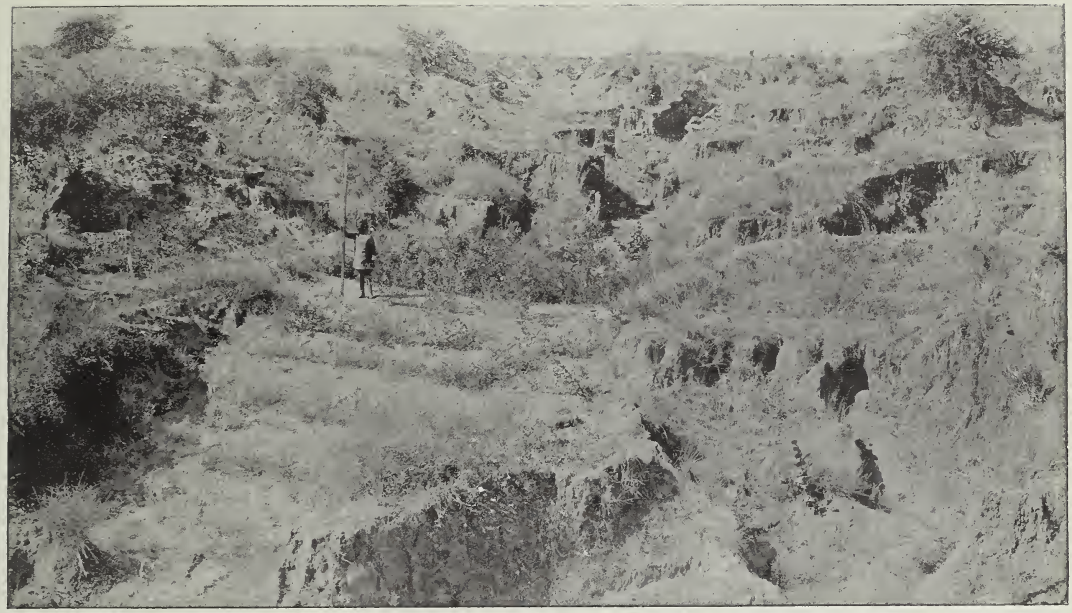
tracts vast quantities of fodder grasses are being left untouched; similarly, while unlimited stores of fuel decay in the forest, the inhabitants of the plains, for want of any substitute, have to burn the cattle manure for fuel, thereby decreasing, or perhaps altogether absorbing, the supply available for manuring their fields and cultivation. And again the absence of adjoining forests renders it impossible for the average villager to build himself anything better than the miserable mud hovel, with which everyone is familiar.

3. But whether afforestation of waste lands in the plains be treated as an economic measure to improve the life conditions of the people, or as a financial proposition, there can be no doubt of the success of such a policy. The existing conditions of intense demand and inadequate supply preclude the possibility of failure, assuming always that it is possible to cover with forest or plantations these extensive wastes at a reasonable initial cost. This note has been written to describe work carried out during the past six years by the Forest Department on a more than experimental scale, in afforesting waste lands of a peculiar but widespread type (the desert-like ravine lands of the Jumna-Chambal tract), which afforded conditions so apparently unfavourable that success had never previously been achieved, and failure was by some experts confidently prophesied.

To Sir John Hewett (late Lieutenant-Governor of the United Provinces) is due the credit of inaugurating a strong Afforestation Policy, while from the start to the present time the energy and enthusiasm of Mr. P. H. Clutterbuck, C.I.E., I.F.S. (Chief Conservator of Forests, United Provinces), has been a strong influence in the success achieved. No reference to this afforestation work would be complete without an acknowledgment of the work done by Mr. Nevill, I.C.S., another moving spirit in the scheme, while the credit for the actual evolution of methods established, and for the organisation and carrying out of details of work done is due to Messrs. Courthope, I.F.S., and Benskin, I.F.S., who were in turn in charge of the Afforestation Division.

4. There is one outstanding point to be noted from the work hitherto carried out. The afforestation of ravine tracts in the Etawah District was a compromise between three schemes, *i.e.*, (1) Ravine reclamation, to prevent further erosion, (2) The creation of fuel and fodder reserves for the local villages, (3) A financial scheme for obtaining a profitable return from waste lands.

Considering the third scheme only, these ra vine tracts selected for afforestation are as badly situated as any area that could be found in the plains. By their very nature, they are comparatively expensive to turn into successful plantations, the lack of communications is deplorable, and some of the plantations are over 25 miles away from the nearest railroad with no facilities for extraction of the produce. If



Head of a ravine being reclaimed. Bandh in foreground. Result of one year's work.

Photo.-Mechl. Dept., Thomason College, Roorkee. Photos. by C. E. C. Cox., I. F. S.

Head of a ravine being reclaimed. Result of two years' work.

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then it is shown that successful and even profitable plantations can be created under such conditions, how much more is it advisable or desirable to treat the more favourably situated areas, the extensive waste lands and gentle ravines in the vicinity of the large towns (such as Lucknow, Cawnpore, Delhi, etc.) or adjoining the railways, and with easy facilities for export of produce to the principal centres of demand.

This point will be referred to again.

This note has been divided into two parts. Part I.—Consists of a general description of the tract, of the usual departmental methods of work and treatment, of results obtained and future possibilities. Part II.—Summarises the experience gained in 1919 in utilising large masses of famine relief labour on ravine reclamation; a special branch of the work which is almost certain to be necessary again, and therefore the very useful experience then gained was considered worth permanently recording in an accessible and convenient form.

The photographs illustrating this note were taken partly by the writer and four instructive photographs on ravine reclamation results have been included by kind permission of Mr. C. E. C. Cox, I.F.S. They show :—

(1) The ravine desert lands before treatment.
(2) The methods of soil preparation by famine labour.
(3) The ravine lands after soil preparation is completed.
(4) Examples of the plantations already created under various conditions.

These photographs will, it is hoped, help to explain the written description, as well as add to the interest of the note.

PART I.

SECTION I.—Past history of Afforestation.

5. The question of utilising the waste lands in Agra, Etawah and adjoining districts and the establishment of fuel and fodder reserves was the subject of a report in 1879 by Dr. Brandis, then Inspector General of Forests to the Government of India.

Report by Dr. Brandis, I.G.F., 1879.

In this report attention was drawn to the large tracts of ravine country lying on both sides of the Jumna river and the extent of wastes to be found in several districts of the Doab.

The measures recommended in this report for the encouragement of forest growth on these lands were (1) The exclusion of fire, (2) Restriction of grazing, (3) The protection from all cutting of wood and (4) Filling up of blank areas by planting and sowing. The report recommended the acquisition of suitably situated and sufficiently large blocks of waste land which should not be too far from the markets of the produce. However the report led to nothing, and no action was taken at that time.

6. The question was revived in 1884, when Mr. J. F. Fisher, Collector of Etawah, started the "Fisher Forest."

The Fisher Forest Plantation, 1884.

The Fisher Forest forms a compact area of 2,852 acres, the nearest point of which is about 1½ miles South-West of the Etawah (East Indian Railway) station along the Gwalior road. It was started in 1884 by Mr. J. F. Fisher, Collector of Etawah, who called together the zamindars who owned the tract of ravine land to the west of the town of Etawah, and these owners agreed to hand over their land for the creation of a fuel and fodder reserve for the protection of the ground from erosion and further deterioration. The owners of the land were to provide the necessary funds, and in return the profits were to be divided *pro rata* according to the money furnished and the land held in each case. The management of the reserve was entrusted to the Collector, who placed the area under working in the same year. Grazing was prohibited, the soil broken with the country plough, and the seed of babul (*Acacia arabica*) shisham (*Dalbergia Sissu*), and Neem (*Melia indica*) sown. In order to dam up the rain water and locally raise the spring level, bandhs (embankments) were thrown across the ravines in suitable places. It appears from the scanty information available that the small expenditure incurred was more than recouped by the sale of grass and subsequently by grazing dues and light fellings. The scheme worked well for a time, and there was eventually a fairly good crop of babul sufficiently dense and valuable to encourage a firm to take over the forest.

In 1902 the area was leased for 50 years to Messrs. Cooper Allen of the North-West Tannery, Cawnpore, for the extraction of babul bark, on payment of R2 per acre and an annual rental of R1 per acre. By 1914 however, *i.e.*, in 12 years, the Firm had practically worked out the whole area, and were glad to transfer their lease to Government for R2,500, who also took over the annual rental payment of R2,832 to the zamindars. The current lease ends in another 33 years.

The Kalpi Plantation, 1904.

7. In 1904 the growing scarcity of babul bark for tanning led to the commencement of the Kalpi Plantation (Jalaun District), of which a brief history may be given :—

In 1902, the Ordnance Department asked for an enquiry into the possibility of increasing the supply of babul bark to the Cawnpore tanneries. Mr. Hobart Hampden, I.F.S., submitted a report in August 1902, as a result of which in 1904, Government acquired 820 acres of waste ravine land about 2 miles south of Kalpi on the Jumna river, and alongside the main Cawnpore-Jhansi railway. The plantation was first owned and looked after by the Ordnance Department, but after a few years they applied to the Forest Department to manage it for them, and it was put under the D. F. O., Jhansi Division, in 1907 and under the Afforestation Division in 1913. In 1915 the Ordnance Department made a free present of it to the Forest Department. For the first 10 years, the results of working were disappointing as for various reasons the sowings of babul were not very successful.

In 1904 seed was sown broadcast over 700 acres in ploughed lines and germinated well, but the severe winter of 1904-05 killed all the young plants. In 1905 the area was resown, but again failed owing to drought, and drought again affected the sowings in 1907 and 1913. In the intermediate years, a certain amount of babul was successfully established. The stock is described in the plantation journal as fol- follows :—

> "Here and there are small well stocked patches, but over large areas there are only scattered isolated young trees."

Failure to establish a complete crop is attributed to the following reasons :—

(1) too large an area was taken in hand at once. The ploughing with country ploughs was too superficial and the sowing in some parts could not be made until too late after the break of the rains.

(2) Weeding, thinning, and subsequent tending, could not be carried out properly over so large an area.

(It may be mentioned here that the results obtained during the last 3 or 4 years with the methods of treatment described below have been excellent.)

8. Again for a long time no further action was taken in the matter of afforesting the Jumna ravines. But in 1912, Sir John Hewett, the Lieutenant-Governor of the United Provinces, issued a most important resolution, in which he defined the policy of Government in the matter of afforestation of denuded areas, and the establishment of fuel and fodder reserves throughout the Province. This resolution was the commencement of a new epoch in the history of afforestation in the United Provinces. An extract from the resolution will indicate the scope of the work which was contemplated :—

"*Among the peasants' greatest needs are firewood to replace manure, small timber for houses and wood for implements, as well as grazing and fodder for his cattle. It has been recognised with increasing clearness that forestry has an important vocation as the handmaid of agriculture, and that she is called to come down from the hills........Sir John Hewett is convinced that a stage has now been reached in the economic development of the Province when a systematic examination of the possibilities of afforestation is imperative........*

"*With the agricultural and industrial development of the Province a rapidly expanding demand for forest produce, and in particular for fuel, small timber, and grass, must be anticipated and the Lieutenant-Governor believes it essential that action should be undertaken to provide well-distributed areas for the production of these commodities.*

"*Afforestation is however a branch of forestry which differs widely from the management of existing forests, and it is a branch in which the officers of the Forest Department have as yet had little experience. The Lieutenant-Governor therefore considers it essential that, before a definite scheme of afforestation is embarked on, a systematic survey of the available areas should be undertaken and that this survey should be combined with a series of experiments on various classes of waste lands with a view to determining the best methods of dealing with different soils, the species best adapted to various conditions and the cheapest and most efficient methods of propagation.*"

In order to carry out the policy thus defined, Mr. Courthope, I.F.S., was deputed to make the preliminary survey of waste lands, and commence the necessary experiments, and the resolution concludes with the following striking sentence; "*Sir John Hewett regards his appointment as the first step in an undertaking which may prove of incalculable advantage to the Province.*"

9. Mr. Courthope submitted his report in 1913. He appears to have been much impressed by the unique opportunity presented in the Etawah district of carrying out the policy and in his reports refers to the vast wastes of this district. Mr. Courthope, after recapitulating the benefits which an agricultural system of improvement would confer on the population, proposed the acquisition of the whole tract of ravine in the Etawah district (over 100,000 acres), and the formation of a forest division with the primary and paramount object of improving the fodder supply and grazing. He deprecated the work being left to private agency as owners were not likely to do more than tinker with the scheme and it was a work without question for the State to undertake. The owners were also considered too poor to undertake the work.

Mr. Courthope's report, 1913.

In order to assist the scheme forward for the afforestation and reclamation of these ravine lands, the owners were approached as regards their willingness to hand over their estates to Government, free of charge, for the purpose of reclamation and in return to receive the surplus profits over and above 4 per cent. on the capital invested by Government, who in return agreed to stand all loss incurred if any area should be abandoned. The owners would however be entitled to purchase back their estate at the conclusion of any settlement at the capital value assessed at the time. As the ravines are at present valueless to the owners, and the grazing at the best of times is of the poorest description, and as the scheme offered possibilities of turning these wastes into valuable pasture lands and fuel reserves, with the possibility of some profit as well, there was no difficulty in obtaining offers of suitable blocks of land, and agreements were entered into with the zamindars for the control and management by Government of 20,000 acres of ravine lands situated near the Jumna and Chambal rivers. In this way the recommendations made by Dr. Brandis in 1879 have resulted in the formation of the Etawah division 35 years later!

10. While this larger scheme was being carried out, afforestation and reclamation experiments were being actively attended to in the plantations previously acquired, *i.e.*, the Fisher Forest at Etawah, the Kalpi Plantation, the Allenbagh at Cawnpore, etc., and the experience gained in these areas proved of the greatest use when the larger scheme was tackled in earnest, so that the preliminary failures which were experienced at Kalpi and Etawah have to a great extent been avoided in the newer plantations.

SECTION II.—Description of the Tract.

11. The Jumna river is one of the principal tributaries of the Ganges. It rises in latitude 31° 2′ longitude 70° 21′ amongst the high snows of the Himalayas, and its total length from source to confluence with the Ganges at Allahabad is 860 miles, of which over 500 miles lie in the Gangetic plain. Between Delhi and Allahabad it has 5 tributaries on the right bank—of which the Chambal river rising in the central India hills, is the most important, and two on the left bank. A characteristic of the Jumna and its tributaries is the very inadequate area of forest lands protecting the banks and head waters, and drainage area generally. In many parts, the vegetation on the neighbouring lands is of a very poor description after centuries of abuse, and the rainfall flows away with great rapidity thereby increasing the volume and violence of the torrents, and leaving their beds dry a few hours after a storm.

Description of the ravines.

12. The accumulated effect of this flooding and scouring has resulted in the banks of the Jumna and Chambal at Etawah being violently eroded during the last 500 years, with a corresponding sinking of the spring level. The cold weather level of the river in the Etawah district is often 120-200 feet below the general level of the surrounding country, and the well water levels are sometimes as low as 120 feet. The banks of the Jumna and its tributaries in many parts are now so completely drained that they have become almost destitute of vegetation except for a desert flora, and even this is disappearing. The absence of protective vegetation on the banks, and the resulting rapid flow or rush of water from the comparatively high flat plateau to the river through the soft alluvial soil has resulted in a vast and intricate network of ravines being formed. These ravines extend for a distance varying from a few furlongs to a few miles on both sides of the Jumna and its tributaries ; they often start suddenly at the edge of cultivation with a drop of some 80 feet or they may be less severe, and they take up a meandering course joining up with other systems, eventually falling into the main river. Standing on any high ridge or promontory, the scene of aching desolation that meets the eye is beyond description. As far as can be seen, parallel to the river, is the wild tangle of barren ravine lands, thrown into greater contrast by the narrow belt of vivid green cultivation along the lower flats of the main river, across which again the interminable ravine desert stretches to the horizon. Not without reason is this inhospitable tract called in the vernacular the "Bahr," *i.e.*, the wilderness. In the Etawah district alone there are 120,000 acres of these barren ravines along the banks of the Jumna, Chambal, Kuari, etc. while further extensive areas occur in Bundelkhand, Jalaun, Muttra, Agra, and Meerut districts.

Ravine country on the Chambal river.

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Illustrates the worthless nature of the unprotected denuded ravine lands.

[To face page 9.

13. The writer would like to record his opinion that one of the principal causes of the existence of this intense ravine erosion is the unlimited and uncontrolled grazing of countless flocks and herds of all sorts of animals (cattle, buffaloes, goats, sheep, camels, asses, etc.) throughout the year. These ravine tracts were once,—many many years ago—a great breeding ground for cattle, and they still produce a magnificent class of goat. The impoverishment of the grazing has increased the impoverishment of the people and is probably a contributory cause in the prevalence of dacoities for which these tracts are notorious. Anyone who has seen (as the writer has) a sudden and heavy downpour of rain turn these dry ravines into roaring cataracts of liquid mud; anyone who has seen (as the writer has) a ravine dry half an hour before, bringing down dead camels and oxen, and becoming dry again in half an hour; anyone who has been washed off his feet (as the writer has) and nearly suffocated in the racing mud, will be convinced for all time of the terrible damage that results from the removal of vegetable growth, and of the urgent need for reclaiming and afforesting these ruined areas.

Cause of ravine erosion.

The Jumna ravines are in fact but another example—a small but striking example—of the world principle that forest destruction means soil destruction, and while the uncontrolled grazing continues matters can only grow worse.

14. This ravine land is at present almost valueless to the owners as it yields practically no good grazing, and absolutely no crops. Cultivation beyond this desert belt is precarious even in years of normal rainfall, and the presence of these ravines render irrigation impossible. Throughout the whole expanse of this ravine land there is no water to be found except in deep wells and in the main rivers. This dry belt is increasing in extent, as the ravines eat into the flat lands at their heads every year.

The general moisture and soil conditions of these ravine tracts are peculiar. The alluvium of the Gangetic plain is of unknown depth and normally one of the most fertile soils in the world. In the ravines however with the hardening effect of the tread of cattle and rapid drainage, the monsoon rains penetrate to a depth of only a few inches and this quickly dries up, leaving a soil almost destitute of moisture down to the spring underground water table 100 feet or more below. It has been ascertained that the occasional scattered trees now found are of great age which have continued to reproduce themselves by coppice shoots, and their root systems have kept pace with the sinking spring level, drawing up their necessary moisture from great depths. Natural reproduction invariably dies down as soon as the rains cease. The vegetation which occurs consists chiefly of *Acacia arabica* (not common) *Acacia leucophloea* and shrubs such as *Prosopis spicigera, Capparis aphylla, Carissa Carandas, Balanites Roxburghii, Zizyphus jujuba,* etc., and the commonest grass is *Aristida Adscenscionis,* a species useless for fodder or grazing.

The climate.

15. A brief account must be given of the climatic conditions of the tract. During the cold weather (middle of October to middle of March), there are usually occasional showers (*i.e.*, the winter rains) in January and February, with an occasional slight frost at night, but bright sunny days. In the hot weather (March to June) the ravines become literally furnaces with shade temperatures up to 120° F. (and in the ravine desert there is no shade) and an intensely hot dry west wind (the Loo) blows strongly all day. There is no sign or sound of man or beast, bird or insect when the Loo is in full blast in the ravines.

Most of the rainfall of the year is concentrated into the 3 months of the monsoon (middle of June to middle of September). Between rain-storms the temperature conditions in the ravines are those of a steamy hot-house, and admirably suited for tree growth. The average yearly rainfall is about 23 inches but the rainfall is most irregular ; 1917 was a year of abundant rain with 55 inches, 1918 was a year of drought and famine with under 9 inches. These famine-stricken years of monsoon failure appear to recur at 5 or 6 years interval the monsoon having failed in 1907, 1913 and 1918.

This brief description of the tract will suffice to give some idea of the extraordinarily adverse and difficult conditions which had to be faced in afforesting these ravine areas. How the problem has been tackled and with what results is described below.

SECTION III.—The Method of Treatment and Reclamation.

The basis of successful treatment.

16. In treating this ravine country, the two great essentials to be considered, are :—

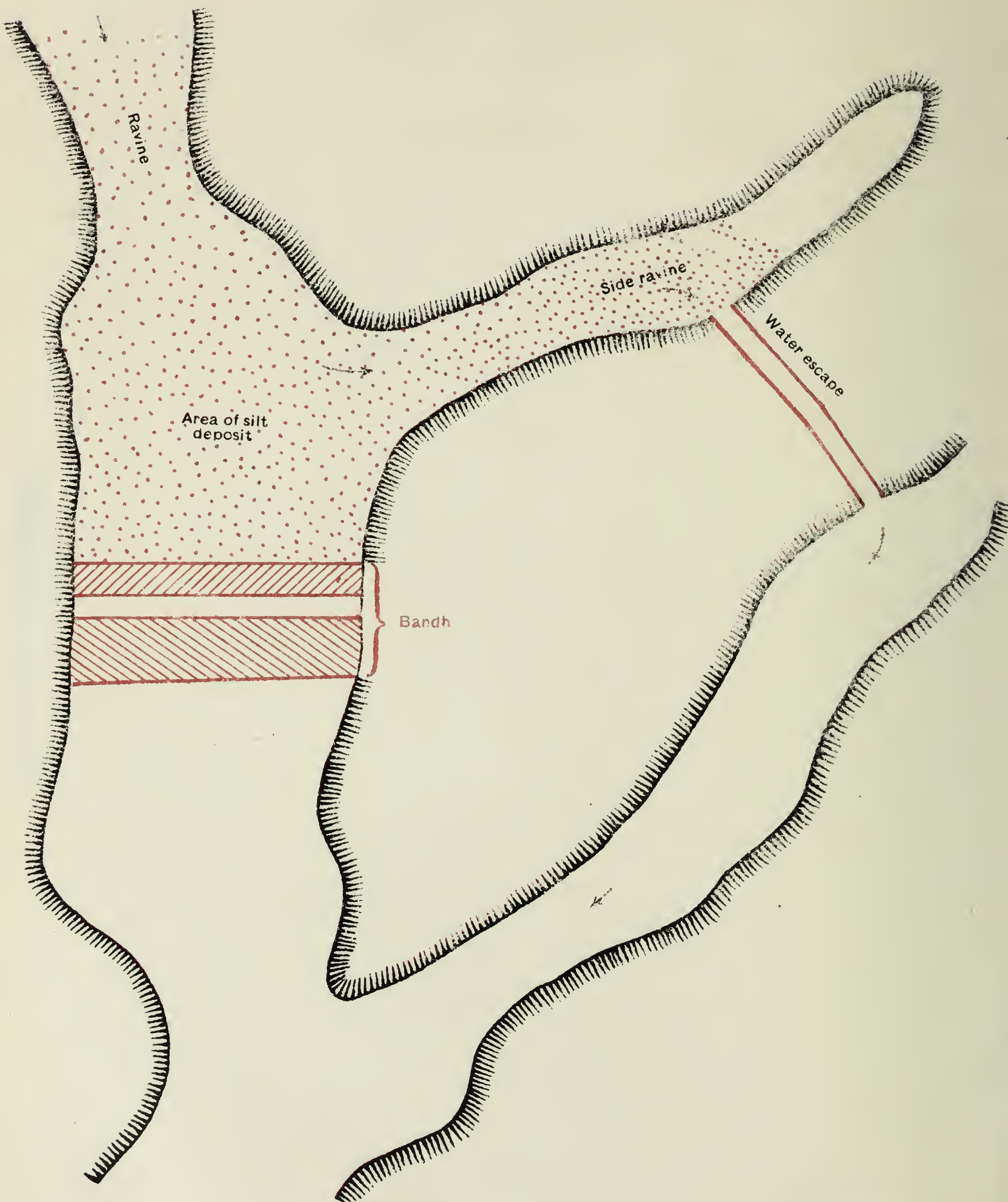
(1) to check further erosion.

(2) to improve the soil aeration and moisture content.

The erosion in the ravine beds is checked (and converted into deposition) by the formation of bandhs or dams across the ravines in suitable places, and the erosion on the sides and at the heads of the ravines is checked by creating an adequate clothing of vegetation. But the vegetation can only be produced by the improvement of the aeration and moisture content of the soil.

A village threatened by ravine erosion.

Sketch to illustrate a Bandh and water escape.

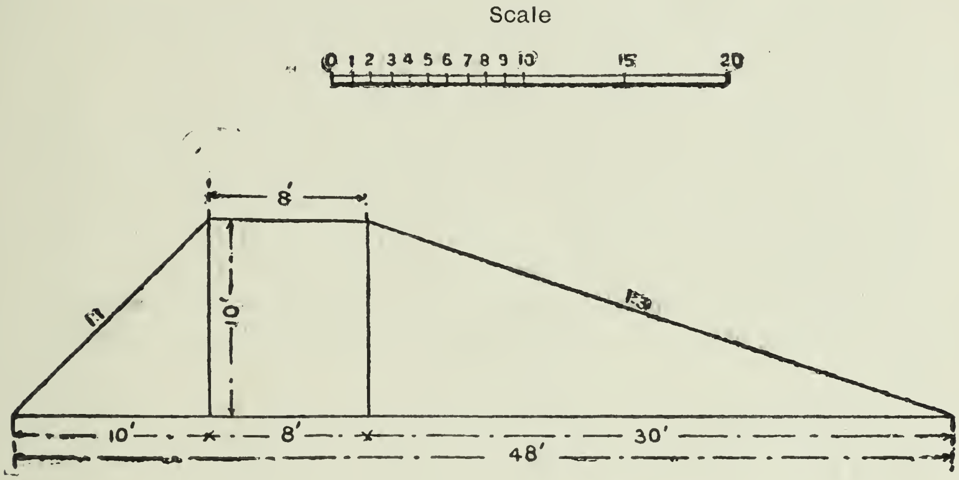


(To face para 17).

The method of bandhing.

Bandhing. 17. The measurements and diagram of a typical bandh are given below :—

NOTE.—The flat top of 6 feet to 8 feet, and the angles of slope are fixed; the height (and base) vary according to the site. The water level is fixed at 2-3rd of total height, and is regulated by the level of the water escape.



Length 60′
Height 10′
Top width 8′
Slopes 1:1 and 1:3

Escape to left of the bandh through cutting.
Cubic contents of bandh 16800 cubic feet.

A plan of a bandh, showing the ravine sides, and the water escape at a distance is also given. The laying out and construction of bandhs have to be done with great care, since if one bandh in a ravine gives way in the rains, the dammed-up waters, suddenly released, nearly always carry away all the bandhs below. The following are the chief points that require attention:—

(1) Bandhing is started at the tops of all the side ravines and work proceeds downwards to the junction with the main ravines. (The main ravines are seldom bandhed at all, because if the side ravines are well done it is unnecessary, and if not, they would never stand the rush of water.) *Every branch ravine should be bandhed.*

(2) In determining the site for a bandh, a controlling factor is the proposed position for the water escape. This must always be as far away from the bandh as possible. If there is a low narrow neck which can be cut through to lead the flood

water to another ravine, the condition is ideal. An escape skirting the edge of a bandh will very soon scour out and undermine the bandh, which will never survive. Frequently a well planned bandh will have a sheet of water stretching to 100 yards on the upside in the rains.

(3) Bandhs must be at right angles to the flow of water, and never in a narrow gorge with steep banks.

(4) The water escape must be capable of taking off all flood water. Its bottom level must be carefully fixed so as to be at least 3 feet below the top of the bandh.

The amount of bandhing required varied considerably with the country. As an example, 250 acres in the Fisher Forest were efficiently and adequately bandhed with 83 bandhs in 1914, or about 1 bandh per 4 acres. Of these about 10 bandhs were broken through in the first rains, but were successfully repaired. Again in 1919, in Bhindwa-khurd plantation, 24 bandhs were made in 108 acres. After one or two years, a bandh is practically safe. It is sown up as soon as possible with shisham, babul, etc., and the growth on bandhs is always wonderful.

On the upper side of each bandh, where a pool of water collects in the rains, considerable silting occurs, and in a year or two a flat broad bed of rich loose fertile loam is formed, on which wonderful tree growth results. Such areas are also utilised for the production of munj grass, *Saccharum arundinaceum.*

The method of afforestation.

Soil preparation.

18. Simultaneously with the bandhing work, the sides and heads of the ravines are prepared for tree growth.

(1) *Preparation of the flat high level land.*

The whole surface is ploughed up deeply with English sabul ploughs, to a depth of 9 inches or 10 inches, and the surface crust thoroughly broken up. (In famine years this work is done by hand to create a big labour demand for the famine-stricken population, as was done in 1919.)

Small parallel ridges (1 feet high and 2 feet broad at the base) 10 feet apart are then made by hand labour, usually with a shallow ditch on the upper side. These ridges act as seed beds, and the soil is kept loose and the clods well broken up, so that the rootlets of the young

Diagram to show system of ditching and ridging on a slope.

Ditches 1′ deep and broad
Ridges 1′ high and 2′ base

Original surface in black.

Prepared ditches and ridges in red.

(To face para 18).

seedlings can penetrate easily. The same method of preparation is employed in the ravine also, wherever the ground is at all flat or gently sloping.

(2) *Preparation of the steep slopes in the ravines.*

With an almost vertical slope, little or nothing can be done, but with all slopes up to 60°, shallow platforms, or ditches and ridges are made on the contour, as illustrated.

The ditches act as silt and water traps, and the mounds as efficient seed beds. Petty irregularities in the surface are at the same time eased off as far as possible, pinnacles of earth knocked down, knife-edged ridges flattened, runnels eroded by rivulets smoothed off, and so on.

All this surface working, bandhing, ditching, etc., has a striking effect on the catchment of the rainfall. For whereas in untreated areas (as already mentioned) the maximum penetration is only 10 inches, in worked areas the soil after a year shows moisture down to 5 feet, and after two or three years when vegetation has been established the water penetration increases up to 10 feet. After two years practically no water escapes the lowest bandhs. The whole surface of the country in fact after two or three years appears altered, the harsh contours are smoothed out, the ravines silted up, the bare craggy banks softened with vegetative growth, and what was a short time ago a pitiless scene of desolation has become a gentle undulating fertile landscape.

Sowing and weeding.

19. This preparation of the land is completed by May. In June when the rains break, babul, shisham, and other seeds are sown on the ridges, babul and *Cassia auriculata* on the steeper slopes and the worst and driest areas, the more valuable species mixed with babul (which acts as a nurse and protection against grazing) in all the best areas, but babul is not introduced in the hollows where frost is possible. The species sown in 1919 were as follows :—

Babul, Shisham, *Cassia auriculata*, Teak, *Gmelina*, Tun (*Cedrela Toona*), Haldu (*Adina cordifolia*), *Holoptelea*, etc.

Germination of seeds takes place within a few days of the first heavy rain. If followed by a long and pronounced break in the rains the seeds which have germinated wither up, thus a bad break may necessitate resowing. Inadequate and scanty rain (*e.g.*, 1918) result in very little seed germinating, and the seed may be dormant in the bed and germinate in the following year. This happened in 1919 with babul and teak.

If things are going well, the small seedlings require a first weeding a fortnight or three weeks after germination. In the latter half of August a second weeding becomes necessary combined with soil loosening, followed at the end of September by a final soil loosening. It is absolutely essential to carry out this thorough tending in the rains, otherwise the young plants get choked with weeds, and cannot develop adequately. A strong and early development of the plant, and especially of the root system is vital, to enable it to survive the following hot weather. *We obtained better results in a year of drought from a well weeded and tended area than from a neglected area in a good monsoon.*

The results obtained thus depend on 3 factors.

(1) The rainfall; other things being equal a year of good rain (*e.g.*, 1916 and 1917) will produce much better results than a famine year (*e.g.*, 1918). But even in a famine year it is possible to raise a good crop of babul (but not of shisham) by the next two factors mentioned.

(2) The previous thorough and efficient working of the soil.

(3) Careful weeding and tending during the first rains. It is most noticeable everywhere that these two factors of intensive treatment are *absolutely essential to success,* so much so, that it is now considered far preferable to do a small area well than a large area indifferently.

Tending and thinning.

20. *Subsequent tending.*—In the second year backward and bad areas are worked again between the lines, the surface being loosened by ploughing or digging. The young plants are also kept free of weeds, and thinned out to 4 feet intervals. From the moment of sowing until the fourth year at least, it is essential to keep out all grazing, especially for the shisham. If an area can be properly protected for four years, the young shisham are safe from danger; otherwise they are perpetually grazed down, except for occasional plants protected by a clump of babul, which shoot up and indicate what damage the illicit grazing has done, and what the growth would otherwise have been like. Other species which are especially damaged by grazing are Tun (*Cedrela Toona*), Haldu (*Adina cordifolia*), and *Gmelina*. In successfully sown areas, where germination has been very profuse, the young seedlings are weeded to 6 inches or 1 foot apart during the first rains. After the second rains, or sometimes even in the first cold weather, the first thinning is carried out, and the young plants left from 3 feet to 4 feet apart. The very vigorous growth necessitates a careful watch being

3–year-old Babul plantation on flat plateau with untreated ravine in foreground.

[To face page 14.

Illustrates soil preparation on moderate slopes with ridges and ditches. Ready for sowing.

[To face page 14.

Typical ravine country with soil preparation completed by famine labour. A bandh with 3-year-old Babul in foreground.

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PLATE IX.

3-year-old Babul plantation on high level plateau.

[To face page 15.

kept on the plantations, to prevent the plants growing up overcrowded. The actual periods and density of thinnings have not yet been standardised, but this will be done in a year or two as the plantations develop.

SECTION IV.—Results obtained to Date.

21. The results obtained from the system of intensive dry farming have been extraordinary, and far exceed original anticipations. Some of the more striking points may be recorded.

Area reclaimed.

The total area converted into plantations during the past 6 years amounts to rather over 2,500 acres of ravine lands. This may by some be regarded as rather slow work, in view of the immense areas to be dealt with. It must however be realised that this ravine reclamation work is in its way unique, in India at least, as nothing like it has been attempted before. It is not surprising that development was at first somewhat slow, there was no previous experience to guide the experiment. The surprise is generally that such success should have been achieved in six years, and now that methods of work have been standardised, it will be possible to accelerate the work.

Prevention of further erosion.

22. It has been established that further ravine erosion can be almost entirely stopped within two or three years (*i.e.*, when the young plants have obtained a good start), provided that the afforestation work has been properly started at the heads of the ravines. When ravine reclamation is limited to the middle and lower portions of a ravine, not only is there nothing to stop further erosion at the top but the race of waters from the unprotected higher reaches renders it almost impossible to keep any bandhs intact. The work should therefore always start at the ravine heads.

Successful plantation.

23. The accompanying illustrations are striking evidence of the wonderful rate of growth of shisham and babul. The following sample plot notes are recorded of the areas illustrated in plates IX, X and XI.

Babul.

Plate IX, sample plot II. Pachdeora block.

Babul mixed with some shisham.

Soil.—A high level flat sandy loam, at the head of a ravine. Soil too dry for cultivation but fertile and of excellent quality when worked up.

Area of plot.—$150' \times 100' = \cdot 344$ acres.

Past treatment.—This area sown with babul and shisham in July 1916, on field ridges and ditches 7 feet apart, first thinning in rains of 1917. The 1918 failure of rains resulted in very little additional growth in 1918-19.

	Plants over 6′ high.		Remarks.
	In plot.	Per acre.	
Babul . . .	402	1,170	Age = $2\frac{3}{4}$ years since germination.
Shisham . . .	74	215	Maximum height = 13′.
			Average height = 9′.
Total .	476	1,385	

Girth measurements at breast height at present too small to record.

Shisham. 24. Plate X.—Sample plot I. Sahson block.

Practically pure shisham, but with 3 or 4 Bakain plants (*Melia Azedarach*).

Soil.—A low lying flat sandy loam, situated in the bottom of a large ravine. Liable to slight inundation in heavy monsoon floods, when the ravine outlet is dammed by the rise of the Chambal river.

This plot to be regarded as on culturable land.

Area of plot. = 115′ × 55′ = ·145 acre.

Past treatment.—Sown broadcast in June 1916, after the soil had been ploughed, and small field ridges made (no trenches). Heavily thinned February 1919.

No. of plants over 10 feet height 170 (=1,100 per acre).

Measurements recorded (12th April 1919):—

Maximum height . . .	= 19 feet.	Age = $2\frac{3}{4}$ years since germination.
Average height . . .	= 15 feet (of dominant crop).	
Maximum breast girth . .	= $8\frac{1}{2}''$	
Average breast girth . .	= $6\frac{1}{2}''$ (of dominant crop).	

1 Bakain (*Melia Azedarach* plant measured.

Height	= 18′
Breast girth	= $7\frac{1}{2}''$

Shisham plants forming seed freely.

Babul. 25. Plate XI.—Sahson block. Pure babul.

Soil and locality similar to adjoining shisham plot described above. An area of exceptionally fine growth.

PLATE X.

3-year-old Shisham plantation in flat bottom of a ravine.

[To face page 16.

4-year-old Babul plantation in flat bottom of a ravine.

[To face page 17.

Past treatment.—Sown on ridges with ditches in June 1915, ridges being 10 feet apart. Number of plants per acre (excluding suppressed stems)=740.

Measurements recorded (July 1919):—

		Ft.	in.	
Maximum height	=	20	6	Plants 4 years old.
Average height	=	17	9	
Maximum girth at breast.	=	1	3	
Average girth at breast	=	0	9	

These figures will suffice to show the growth of shisham on good areas, and of babul on good and on average areas.

Miscellaneous.

26. Apart from shisham and babul, however, numerous other tree species have been tried experimentally chiefly in the Fisher Forest, on a high level dry, flat sandy loam, a very average locality. The following record of measurements may be noted:—

Species Botanical name.	Vernacular name.	When sown end of June.	Height end of June 1918.	Height end of June 1919.	Increment in 1 year of drought.	REMARKS.
			Ft. in.	Ft. in.	Ft. in.	
Tectona grandis .	Teak .	1915	17 3	18 0	0 9	
Shorea robusta .	Sal . .	1915	2 0	2 5	0 5	
Dalbergia Sissoo .	Shisham .	1916	12 4	16 1	3 9	All measurements recorded are average of 3 best plants.
Acacia Catechu .	Khair .	1917	4 4	5 3	0 11	
Acacia jacaranda .	Jacaranda.	1915	15 0	15 9	0 9	
Bombax malabaricum	Semel .	1916	8 2	10 5	2 3	
Gmelina arborea .	Gumhar .	1916	14 10	18 0	3 2	
Holoptelea integrifolia.	Papri or Kanju.	1916	7 8	9 8	2 0	
Adima cordifolia .	Haldu .	1916	5 6	7 6	2 0	
Hardwickia binata .	Arjan .	1916	7 6	10 0	2 6	

The relatively small increase in growth in 1919 was due to the phenomenal drought. There was no growth at all from October 1918 to July 1919, but it is noteworthy that scarcely any established plants were killed by the drought, and when abundant rains came in July 1919, all species shot ahead rapidly. These results are encouraging, and experiments are now being tried on a large scale.

Improvement of fodder and grass.

27. The effect of intensive cultivation and protection on the improvement of the fodder crop is noticeable. The common and worthless species of ravine grass, sufaid lapa (*Aristida Adscenscionis*), disappears, and gives place to such valuable fodder grasses as Dub (*Cynodon dactylon*, Pers.), *Apluda varia*, and the smaller spear

grasses. The quantity also increases enormously. From untreated ravines, no hay at all is obtainable. The following figures for two of the older protected plantations are instructive :—

	Area closed acres.	YIELD OF CUT HAY 1918-1919.		REMARKS.
		Total mds.	Per acre.	
Kalpi . . .	1,385	9,600	7·0	The drought of 1918 materially decreased the normal supply of grass.
Fisher Forest . .	750	3,750	5·0	

After the removal of the hay crop, a considerable amount of grazing was still left.

This supply of fodder grass is useful at all times, and invaluable in years of deficient rainfall, in those very districts of the Province where shortage and famine are most frequent and most difficult to alleviate. During 6 months in 1919, Government was importing large quantities of hay from the submontane forests to keep the cultivators' cattle alive on which a loss of about 0-10-0 to 0-12-0 per maund was incurred. When an adequate area of ravine lands has been reclaimed, the cultivator will obtain a superior fodder at a lower price at his very gates, and with no loss on expenditure to Government. The districts will in fact be practically safe from fodder famines.

Dangers to which the plantations are liable.

28. A word must be said to indicate the cause of damage and dangers to be reckoned with in these plantations. Emphatically first and foremost comes uncontrolled grazing. In the first three or four years all grazing has to be stopped, until the young plants are safe from damage. But it will never be possible to have unlimited and uncontrolled grazing in reclaimed areas. As has been pointed out above, one of the principal causes of the ravine erosion has been the removal of the protective vegetative growth in the past by uncounted flocks and herds of camels, sheep, goats, donkeys, and cattle, and if this should occur again in reclaimed areas the ground would again be stamped hard and impervious, soil aeration and water absorption would vanish, and the tree growth would gradually vanish with it. To limited and controlled grazing, however, after a few years there can be no serious objection.

Natural causes have so far not done any serious damage. The 1918 drought killed a few scattered shisham plants and groups on high dry lands, and frost has done some damage amongst babul in low-lying hollows, while strong winds occasionally uproot fast grown plants, especially when white ants, porcupines, mice or other animals have damaged their base or root system.

But the damage done hitherto is of very small importance, and we are justified in thinking that natural causes will not prevent the areas reclaimed from becoming successful and flourishing plantations.

SECTION V.—Future possibilities and suggestions for future management.

29. Excellent and promising as are the results obtained to date, they by no means absorb all the possibilities that lie before the afforestation of these ravine lands.

Experimental introduction of new valuable species.

Some of the experimental introductions of valuable plants which are being tried may be briefly mentioned.

(1) *Timber trees.*

Cedrela Toona (Tun), a valuable furniture wood, fast grown, suitable for growing in ravine bottoms.

Holptelea integrifolia, an ideal timber for bobbins, fast grown and not grazed by animals.

Adina cordifolia. (Haldu), another excellent timber for bobbins, and the demand for this timber exceeds the available supply. (Some plants in the Fisher Forest show a growth of 10 feet in 3 years.)

Anogeissus latifolia (Bakli or Dhauri), a hard wood ideal for tool handles, and for which there is a growing demand. This species grows naturally on hot dry southern slopes in the submontane forests.

Bassia latifolia.—The well known Mohwa.

Terminalia Arjuna, a valuable constructional timber, suitable for ravine bottoms.

Cinnamomum Camphor, the camphor tree.

(2) *Grasses.*

The Baib or Bhabar grass (*Ischæmum angustifolium*), a plant of great promise for these ravine tracts. It grows naturally on hot dry slopes, is an excellent soil binder, and a good fodder grass so that its introduction should be of great use in years of fodder famine and drought; it is one of the principal raw materials for paper making in India, so there would always be a demand for it; useful also for rope making and a variety of other purposes.

Munj grass (*Saccharum arundinaceum*).—A valuable thatching grass, and useful for introduction in the areas above bandhs which are liable to be swampy in the rains.

(3) *Fodder trees.*

A few cuttings are being put in per acre of trees which are valuable for fodder, such as *Ficus religiosa* (Pipal) and *Ficus infectoria.* With two or three trees per acre available for lopping in famine years, the severity of fodder famines would be greatly alleviated.

The above list will suffice to show what is being attempted this year. Year by year the possibilities of these ravine tracts will be tested by the introduction of other species of economic importance, and this will constitute one of the principal branches of research by Afforestation officers in connection with these ravine tracts.

30. Regarding the financial returns which may be expected from the afforestation of these ravine tracts, it is at present impossible to make any definite estimates. With only three years growth to guide us, we cannot forecast how long it would take for the trees to be ripe for the axe, and moreover we know already that the rates of growth will vary enormously between the fertile ravine bottoms and the dry high plateaux.

Again, if we succeed in obtaining early and frequent returns (*e.g.*, by the introduction of such species as *Cassia auriculata,* Bamboos, and Baib grass (*Ischœmum angustifolium*), the financial aspect is enormously improved ; and finally, the financial return from every plantation is bound to be largely dependent on its accessibility and proximity to the market. For well situated plantations, near railways or large towns, there is undoubtedly a splendid financial future, but there are some plantations—30 miles from a railway by inferior roads, with two, or three large unbridged and often unfordable rivers to cross in between which can never be expected to do more than pay their way, the difficulties and cost of export of material absorbing all potential profit.

This is all that can be said at the present time on the financial future of these plantations. Five or ten years hence it will be possible to write a second edition of this note, giving much fuller information. But in afforestation of ravine lands, the financial aspect is emphatically *not* the only criterion, whereby to judge the success or failure of the venture. The prevention of further erosion, and the creation of fuel and fodder reserves for the local villages is of equal or greater importance and from this point of view, every plantation will prove successful.

The cost of creation per acre is given in an appendix.

31. In a report on the extension of afforestation work recently submitted to Government, the lines of policy for the management of these plantations were described. These may be briefly outlined here, as they will probably prove the basis of management for many years to come, if sanctioned by Government.

Teak saplings, four years old. Fisher Forest, Etawah. Maximum height 22 feet.

[To face page 20.

Gmelina arborea, 3 years old. Fisher Forest, Etawah. Height 25 feet, girth 12" at breast height.

[To face page 21.

After indicating the three objects of management (*i.e.*, (1) ravine reclamation, (2) fuel and fodder reserves for the people and (3) financial results), and the three parties interested in the ravine reclamation schemes (*i.e.*, (1) the local cultivators who are generally tenants of (2) the large landowners, who get no profit from these waste lands, and (3) Government, who raise the necessary capital and staff for the afforestation work), the following proposals were made :—

The villagers should get—

A certain proportion of all the ravine lands round a village to be left unreclaimed and open to existing unlimited grazing, hacking about and present abuses. The necessity for this lies in the fact that the villagers must have some area in which to exercise and graze their camels, goats, donkeys, and superfluous cattle.

In the areas reserved for afforestation they should have—

(1) Free grass cutting, of indigenous species.
(2) Free fuel.
(3) On payment, limited or controlled grazing, and subsequently poles, timber, bamboos, or any other produce artificially introduced, and to which they could claim no right.

The large landowners should get :

(i) Certain personal rights, *e.g.*, to shooting, produce for themselves, etc.
(ii) The cash surplus after Government had paid back to itself the capital invested and interest. Alternatively they might have a fixed yearly rental.

Government would benefit by the general well-being of the people, and by the prevention of further erosion. The money invested (with interest) would in time be paid back out of profit.

32. A few remarks on the future technical management of this afforestation work may not be out of place.

Need of a Working Plan.

The work carried out hitherto, both as regards methods of treatment and species introduced was largely experimental, and it was not possible to forecast accurately what results would be obtained. The experimental phase is however passing, the method of treatment has been very largely standardised, and given normal rainfall, it is now possible to forecast more or less what results may be expected. The preparation of a carefully drawn up working plan or plantation scheme is therefore not only now possible, but is unquestionably urgent. But for the intimate knowledge possessed by Mr. Benskin, (recently in charge of the Division), of every corner of the plantations, and of every phase of the work, the need for a scheme or plan would have been realised before.

Difficulties in future management.

33. Without such a plan, there will be a decided possibility of laying up difficulties for our successors. The silvicultural management of these plantations 20 years hence will not be a simple matter anyhow. The locality presents us with an intense intermingling of areas of very different growing capacity (*i.e.*, the ravine bottoms on the one hand, and the dry slopes and plateaux on the other hand) this will result in mixed crops, with valuable hardwoods in the ravines (shisham, tun *Cedrela Toona*, etc.), and the less valuable babul, *Cassia auriculata* and possibly *Anogeissus latifolia*, on the slopes and plateaux. The babul will be felled largely as poles (possibly treated as coppice), while the valuable species will probably be grown to large timber; thus the rotations will be very different. The physical conditions preclude the possibility of growing extensive areas of one species only, and this fact renders the preparation of a carefully thought out working plan all the more necessary.

The need for introducing several species.

34. When this afforestation work was started, the original idea was to grow pure or almost pure babul, the chief profit from which lies in the value of the bark for tanning. But the tanning industry is limited, while the possibilities of babul bark production are almost unlimited, and it would be a dangerous policy to base our hopes on one species only with the possibility of over production. Moreover there are other industries to be considered also, which require only the raw material to show a great development, while the demand for poles and constructional timber is always growing and efforts should be made to try and meet it. Hence the necessity for continuing our experimental introduction of valuable timber species, even at the risk of complicating the subsequent silvicultural management.

When the plantations begin to be felled over, new industries and new demands for labour and employment will be created, to the general well-being of the surrounding community.

35. It has already been recorded that the waste and uncultural lands in the Provinces as a whole exceed 8 million acres. The area of ravine lands demarcated for plantation work in the Afforestation Division total only 20,000 acres, of which less than 3,000 acres have so far been done, and as results so far obtained become more widely known, owners of waste lands will begin (and have in fact already begun) to show great interest in the possibilities of afforestation of their at present profitless lands. Large landowners, Court of Wards estates, Cantonment, Railway, and Canal authorities, Improvement Trusts in the large towns; all these and others have already initiated enquiries or asked for expert advice on the possibility of creating plantations for profit. Unquestionably there is a great expansion coming

in the near future in afforestation of waste and unculturable lands in the Gangetic plain, and one of the principal objects in preparing this note has been to expand the circle of recognition, and enable the public to appreciate the possibilities of the work.

APPENDIX.

Cost of creation and upkeep of Ravine Plantations.

The following general rates are sanctioned in the Afforestation Division :—

I. Soil preparation—	
(1) Ploughing on flat or undulating ground .	Rs. 3 to 4 per acre.
(2) Making field ridges on ploughed land .	Rs. 5 to 6 per acre.
(3) Making ridges with ditches on unploughed land, steep slopes, etc., including a little cliff breaking and breaking down bumps, pinnacles, etc.	Rs. 20 to 24 per acre.
(4) Bandh construction	Rs. 5 per acre or 3-8 per 1,000 c. ft.
II. Sowing (including collection of seed) . .	As. 12 to Re. 1 per acre.
III. Tending and weeding in first rains, each weeding Rs. 1-10-6 per acre, or with 3 weedings	Rs. 5 per acre.
Filling up gaps with shisham cuttings and other transplants, planting grass roots, etc. .	As. 10 to Rs. 1-6 per acre.
IV. Subsequent tending and miscellaneous—	
Thinning (2 to 4 years old)	As. 8 per acre.
Fencing with thorns	As. 6 to 9 per acre.
Cattle guards and Forest guards . . .	As. 8 per acre per annum.

The general cost of creation and upkeep of plantations, excluding—

(1) Acquiring the land and preliminary demarcation.

(2) Wire fencing.

(3) Overhead and supervising charges, may be put roughly as follows :—

Details.	On flat lands without bandhs per acre. (*a*) Rs. A. P.	Moderate in ravine lands with bandhs per acre. (*b*) Rs. A. P.	REMARKS.
			Total initial cost—
Soil preparation . . .	10 0 0	25 0 0	1. flat ground Rs. 18.
Sowing, tending and protection for 1st year.	8 0 0	8 0 0	2. ravine land Rs. 33.
Subsequent tending and filling up failures.	0 8 0 (per annum)	0 8 0 (per annum)	Total recurring expenditure Rs. 1-8-0 per annum.
Miscellaneous recurring expenditure. (Roads, Tools, etc.).	0 8 0 (per annnm)	0 8 0 (per annum)	
Stuff	0 8 0 (per annum)	0 8 0 (per annum)	NOTE.—The budget allotment for 1920 in the Afforestation Division for 1,600 acres is Rs. 44,000 or Rs. 27-8-0 per acre.
TOTAL .	18 0 0 *plus* 1 8 0 (per annum)	33 0 0 *plus* 1 8 0 (per annum)	

These figures should prove useful in preparing estimates for new plantations, for financial forecasts and the like.

PART II

Ravine Reclamation and Famine Relief.

Being a note on the experience gained in the Etawah district in the 1919 famine.

Introduction.

In the autumn of 1918, when the complete failure of the monsoon had made it clear that there would be severe scarcity in the ravine tracts of the Etawah district, Government decided that the principal form of famine relief in those tracts should be ravine reclamation work. This was a form of relief that had not been tried previously to any appreciable extent, and the Famine Code, comprehensive as it is, does not in many ways cover this type of work. Moreover, few Forest Officers in these Provinces know much about the Famine Code, or have had occasion in the past to study it intimately in its actual working. With probable extension of afforestation and ravine reclamation work in the Province, and with the certainty of recurrence of famine operations (in the Jumna-Chambal ravine tracts especially), at fairly frequent intervals, the need of some guide or record for this type of work becomes apparent. This note has therefore been drawn up on the experience gained in the 1918-19 famine in the Etawah district. Although primarily from the Forest point of view, and to serve as a guide to the Forest Officer, it will, it is hoped, also prove of some value to Collectors, Famine Officers, and others within whose charge this type of famine relief work is adopted.

The absence of all previous experience of famine relief work in ravine reclamation led inevitably to a few mistakes in the beginning. The account procedure was new to the Forest staff, while the standardisation of tasks, the organisation of gangs, the checking of continually shifting work, and many other points had to be ascertained by practical experience before the work could run smoothly and properly.

This note will, it is hoped, help to smooth over the initial difficulties when ravine reclamation work is again carried out by famine labour.

2. A description of these ravine tracts, and the methods and objects of treatment have been given in detail in Part I (paras. 12 to 20) of this note, and need not be repeated.

There are several factors in this ravine reclamation work which make it a very suitable form of famine relief. These may be briefly indicated—

(i) The variety of work affords employment for every description of unskilled labour, for men, digging and cliff breaking, for women, ridging and carrying earth, for the old and feeble

Famine labour employed in breaking down a steep slope.

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and for quite small children, clod breaking on the bandhs and ridges. (The details of organisation and classification of gangs are given in the next chapter.)

(ii) It is a form of work which (unlike other relief works such as roads or buildings or tanks) can be started or stopped at any time, without rendering useless the work previously done.

(iii) It will in time prove directly remunerative, besides affording a permanently improved fuel and fodder supply to the neighbourhood.

(iv) It is singularly well adapted to small civil works, scattered about in the vicinity of the famine stricken villages. In fact labour should be definitely limited to a maximum of 800 to 1,000 on any one work, as larger numbers are difficult to control. *It supplies work to the people near their villages.*

(v) The gangs of 30 to 50 work more or less separately, and the work is always moving on to new ground. This is a favourable factor for sanitation and prevention of cholera or other infectious diseases.

(vi) Reclamation work is peculiarly flexible and elastic, and a scheme of work prepared before the famine starts can be easily and quickly adapted or added to or altered, to meet altering conditions of labour supply.

Preparation of famine relief scheme.

3. When the monsoon failure indicates clearly that famine operation will be necessary, the Forest Officer in consultation with the Collector, has to draw up the scheme of work to be followed, if such scheme is not already prepared.

The Collector indicates roughly where relief works will be required and how much labour at each may be expected. The areas to be worked over are then fixed, and the boundaries clearly demarcated by a dag-bel on the ground. It will enormously facilitate subsequent checking and control if rectaugular 10 to 20 acre plots are dag-belled out, and numbered, two or three or five or more such plots being marked at each work as required. Simultaneously the bandhs required in these plots have to be selected, their sites pegged and dag-belled, their dimensions taken and tracings prepared, and their water escapes clearly defined.

This work has to be completed before the opening of any test work which itself precedes the declaration of famine.

PART II.

SECTION I.—Organisation of labour and tasks.

The essentials of famine relief works.

4. Before describing the organisation of labour and fixing of tasks, a brief account of what famine relief work is, will help the non-initiated Forest Officers to understand what follows. It consists essentially of daily labour work on a gigantic scale*, with all sorts and conditions of labour (from stout men to infants-in-arms), which is all carefully graded into 5 or 6 grades; each grade has its standard daily wage. Wages are paid daily in annas and pice to every man, woman, and child on every work, after the daily tasks have been measured up. Tasks not completed to standard lead to small fines. Daily labour muster rolls are kept up by gangs and grades of labour, but no signatures or thumb impressions taken. These details of working conditions will suffice to indicate the necessity of really good organisation of labour, staff and tasks, to avoid confusion. When it is added that there are black sheep in every fold, but famine works appear to draw more than the usual proportion, the further necessity of most elaborate check and constant supervision becomes apparent.

Organisation of labour and staff.

5. The grades of labour. These are defined in the Famine Code. They are summarised for clearness of subsequent details.

Labour—

B. Strong men and women.

C. Weak or old men and women, youths and maidens of 15 or 16 years old.

D. Children 10—14 years of age.

G. Children 7—10 years of age.

H. Infants-in-arms.

A. Mates of gangs.

Foremen.—One foreman to 150 labourers.

Managers.—One to each work.

Circle Officers.—(*i.e.*, Range officers) in charge of 5 to 6 works and 3,000 to 5,000 labourers, which is as much as one Range officer can adequately look after.

He must see each work once a week.

*NOTE.—To give an idea of scope of the work, payments in *Forest* famine works in the Etawah district in 1919 exceeded Rs. 1,000 daily when the work was in full swing, distributed between 15 works which were scattered over 50 miles of country. The famine labour on ravine reclamation under the Divisional Forest Officer, Afforestation Division, amounted to more than half the famine labour for the whole Province.

Famine labour making ridges and ditches on a steep slope.

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Famine labour employed on bandh construction.

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The D. F. O. in charge of from 12 to 20 works, 10,000 to 15,000 labourers, which is as much as he can control.
He should see each work once a month.

The labour that comes to the work is classified and divided into gangs. Most of the work consists of—

(1) Digging.

(2) Ridging.

(3) Bandhing.

A digging gang consists of 30 B units (either male gang or female gang).

A ridging gang consists of 30 C units (male and female mixed) with a corresponding number of D or G units. One worker makes the trench and ridge, while the child breaks up the clods on the ridge, to make a suitable seed bed for the development of the young seedlings.

A bandhing gang consists of—

10 or 12 diggers.

10 to 20 C earth carriers.

10 B or D rammers.

10 to 20 or more G children and feeble old folk for clod breaking.

A variety of miscellaneous jobs on each work also absorb each its own small gang, *i.e.*, (4) Fencing. (5) Well-making, (6) Clearing trees and shrubs, (7) Water supply, (8) Road making, etc.

Standardisation of Tasks.

6. The standard daily task for every type of work has to be clearly defined. After a good deal of trial and experiment, the following standard tasks were finally adopted in the Etawah 1919 famine work.

(i) *Digging.*—The varieties of soil hardness in these ravine lands are so considerable that one standard task for all conditions of soil was found to be impracticable. The following variations were adopted :—

(*a*) In soft flat ravine bottoms, and where the soil had been worked in previous year.

1. B man—160 c. ft. (160 sq. ft. to 1 ft. depth).

1. Gang of 30 B men—4,800 c. ft.

(*b*) On average unworked land, and moderate slopes—

1. B man—120 c. ft.

1. Gang of 30 B men—3,600 c. ft.

(*c*) On hard kankar ridges and very steep slopes—

1. B man—100 c. ft.

1. Gang of 30 B men—3,000 c. ft.

(*d*) Digging water escapes for bandhs. Individual task—

1. B man—84 c. ft., *i.e.*,
   - 7 feet long.
   - 6 feet broad.
   - 2 feet deep.

For B women gangs for (*a*) and (*b*) the task was $\frac{2}{3}$ of task for B men gangs.

(according to Famine Code rules, a woman is paid the same as a man but does $\frac{2}{3}$ of his work.)

(ii) *Ridging.*—This work involves digging a trench, 1 foot deep and 2 feet broad (in soil previously dug by digging gangs) and heaping the soil therefrom in a triangular ridge on the down hill side.

Tasks—

B. men 60 running feet of trench.
B. women 40 running feet of trench.
C. class 40 running feet of trench.
D. and G. children. Breaking clods on the ridges.
1 child to one ridger (very old and feeble men and women are often used on this work also).

(iii) *Bandhing.*—The tasks were based on the diggers. For 12 diggers task was 1,440 c. ft. of earth. For the C class carriers employed, the task was to carry this dug earth to bandh site (12 to 20 carriers employed). The children had to pulverise this quantity of earth on the bandh, and the rammers to ram it hard.

Other miscellaneous tasks were :—

(iv) *Fencing.*—One gang of 10 to 12 B men per work. Task 15 to 22 running feet of hedge per man, including collection of thorny shrubs, etc. The hedge was 5 feet thick, with stout thorny branches fixed into holes on either side, and centre filled in with loose thorns.

(v) *Water supply.*—The gang varied with the distance of water and numbers on the work, and the season ; up to the end of April, one man for every 300 labour for every furlong the water had to be brought. In May, increased to one man for every 150 labour, for every 150 yards.

(vi) *Well making.*—The gang consisted of one mate (an experienced well digger), 3 or 4 diggers—task 80 c. ft. per man. 3 earth removers, increasing to 4 as the well deepened.

These are the principal tasks. The adjustment of digging tasks was left to the manager on the spot under the control of the Range officer. Experience at every work opened always showed a plethora of old and feeble men and women, and young children, who could do nothing but clod breaking. As employment has to be provided for all who come to works (under the Code, only lepers and lunatics may be refused), a comparatively large number of bandhs had to be laid out, as bandhing work absorbs more clod breakers than any other.

Scale of wages.

7. An idea of the scale of wage paid will be of interest to Forest officers, unaccustomed to labour conditions where villages turn out *en masse* to work, in order to live.

The wage scale is controlled by the price of the common food grain. In Etawah in 1919, the following wages were generally paid for a full day's work :—

Class of labour.	Daily wages.			REMARKS.
	Rs.	A.	P.	
B men and women	0	2	6	Wage basis—price of grain = $6\frac{1}{2}$ seers.
C (old and feeble) adults . . .	0	2	3	
D children (10—14)	0	1	3	
G children (7—10)	0	1	0	
Infants-in-arms	0	0	3	

SECTION II.—Checking and control.

Accounts.

8. The accounts procedure is given very fully in chapter XIX of the Famine Code. But a brief summary of the main outlines as far as they concern the D. F. O. and his Range officers will possibly prove of assistance, as the procedure is very different to ordinary Forest Accounts. The system is based on a permanent fixed advance. Everyone has an advance of varying value, *e.g.*, a works manager has an advance equal to three days' expenditure (Rs. 100 to Rs. 300)*, received from his Range officer.

The Range officer has an advance equal to 10 days' expenditure (Rs. 2,000 to 4,000). He keeps some in cash and advances some to his works managers, who draw on him for more when their allotment is spent.

The Divisional Forest Officer has a fairly large advance (Rs. 12,000) which he distributes to his Range officers and a little to his famine Head clerk.

* The figures of advance show the amounts given out in the Etawah 1919 famine, to give some idea of their magnitude.

Every Saturday afternoon works managers prepare the consolidated weekly summary for their work and submit it to their Range officer. He consolidates for his Range and submits to the Divisional Famine office on Sunday morning.

The consolidated accounts for the Division have to be ready and submitted to the Collectorate on Monday morning. Obviously there is no scope for dilatoriness or unpunctuality.

Then on Monday the exact amount of the weekly expenditure is obtained from the Treasury, and distributed exactly according to their accounts to Range officers.

Thus everyone is again in receipt of his full permanent advance and so it goes on week after week.

There are of course no monthly accounts. The audit of accounts is done in the Collector's office.

Control of work.

9. The Divisional Forest officer is solely responsible for all technical details, for the character and quantity of work done, for the fixing of tasks, for the laying out and construction of bandhs, and all similar details.

He is also very largely responsible for the due observance of Famine Code procedure, but in this he is largely helped by the Collector and his inspecting officers who bring to notice mistakes occurring in procedure.

For Forest Famine works, intense supervision and continual surprise inspections are absolutely essential, more so than for any form of Departmental Forest work with which the writer is acquainted. This intense control is necessary not only to prevent swindling by Works Managers and Foremen, but to keep the work up to the mark and ensure that full tasks are done.

The complete check and inspection of a Forest Famine Work is a long business ; para. 42, Appendix D, of Famine Code, details some points to be looked to, but the Forest officer had in addition to examine and check the technical work. Experience only will show how a famine work should be inspected, it cannot be explained. It takes over three hours to do properly and is rather an ordeal to carry out day after day in the middle of the hot weather in the pitiless shadeless ravines, with a shade temperature of 110° to 120° F.

SECTION III.—Miscellaneous.

Cost per acre.

10. There are several miscellaneous points worth recording as a result of experience gained in the 1919 famine work. One point is the cost per acre. It must be emphasised that the cost of soil preparation by ordinary Departmental methods is no criterion or standard when estimating

for famine work, for several reasons. The main reason is that the work is done far more thoroughly by famine labour than we can possibly attempt to carry out departmentally, when the capital cost of creating plantations has continually to be borne in mind. The enormous mass of labour that has to be accommodated at famine time would result, if worked on ordinary lines, in preparing such an enormous area of new plantation that the subsequent sowing up and tending during the rains (when famine labour is no longer available) would be almost impossible. In fact the area worked is kept within workable limits by *increasing the intensity and quality of the work.* Again the preliminary soil loosening is normally done by ploughing in all flattish areas, and left undone on steep and precipitous slopes, but in famine time digging by hand labour is substituted and is done everywhere, both on flat ground and steep slopes. Finally the employment of numbers of old and feeble folk and young children, and various miscellaneous expenses not usually incurred (*e.g.*, establishment (5 per cent.), mates (5 per cent.) water supply and well digging (5 per cent.). etc., add quite 20 per cent. to the cost of the work.

The cost per acre varies considerably with the locality, especially with the degree of steepness of the slopes. A calculation was made for an acre of fairly steep ravine land, and worked out as follows :—

Cost of soil preparation of 1 acre.

Nature of work.	Units of work.		Cost of 1 unit. annas.	Approximate cost per acre. Annas.	Remarks.
	Class of labour.	No. of units.			
(1) Digging . .	B	500	2½	1,250	
(2) Ridging . .	C D or G	150 150	2 1¼	500	
(3) Bandhing . .	B C D C	25 to 50 50 to 100 50 to 70 25 to 50	2½ 2 1¼ 1	250 to 300	Bandhing very variable.
(4) Miscellaneous. (20 per cent. of above cost).	...	add 10 per cent. of above	...	400 to 450	For miscellaneous works add 10 per cent. to No. of work units and 20 per cent. to total cost.
Total cost .	B C D G	600 250 200 100	... ...	2,400 to 2,650	

This gives roughly a cost of R150 to R165 per acre. Mild ravine country would reduce 25 per cent., while really bad and precipitous ravines, with 50 feet to 80 feet sheer drops increase the cost indefinitely. (It is not economical to work such areas at all from a plantation point of view, but sometimes they must be worked to check further erosion.)

Intensity of soil preparation.

11. The outlay given in this table represents the working of the soil with extraordinary thoroughness (see photograph), far beyond anything that has ever been attempted before. (As a natural consequence, the plantation results promise to be excellent.) The cost per acre can however materially be reduced (without any serious difference in the subsequent success of the plantation) by omitting the breaking down of unnecessary precipitous slopes, and by omitting the wholesale digging of steep slopes (on which the presence of the loose soil tends to fill up the water ditches). The intensity of soil preparation is in fact a most useful regulating factor; as already indicated when the famine is severe and large numbers are expected on famine relief works, the soil preparation must be intense to keep the area worked within reasonable limits ; if the famine conditions are less severe, less intensive working will avoid a corresponding reduction in worked area. In the Etawah famine of 1919, there was no previous experience to guide us. When the scheme of work was prepared in the previous autumn, double the number of famine units of work were expected that actually came, the area worked was expected to reach 1,500 to 1,600 acres, which was as much as the Forest Staff could have dealt with in the rains ; actually about 900 acres of land were prepared. It will be useful to bear this point in mind on a future occasion.

Conclusion.

12. In conclusion it may be useful to summarise briefly the results of experience gained in the 1919 famine in the Etawah ravines.

(i) Ravine reclamation is eminently suited to famine relief work.

(ii) It requires however by its very nature, by the variation in tasks, by the scattered working, by the continuous shifting of work, considerable intensity of supervision and inspection, more so than is required normally for other forms of famine relief work. Controlling charges must therefore be limited in size.

(iii) With intense soil breaking, the cost comes to about Rs. 150 to 160 per acre for average ravine country, and the No. of work-units per acre (*vide* table in para. 10) roughly—

Adults	800
Children	300
TOTAL	1,100

(iv) The number of work units and cost per acre can be naturally reduced if necessary by leaving sheer cliffs unworked (where further erosion is not to be checked) and by preparing ridges and ditches on steep slopes without soil working in between. In any one locality there is a definite maximum area which can be successfully tended in the rains; this has to be borne in mind, and considerable variations in labour supply can to some extent be balanced by variations in intensity of soil working.

(v) The standard tasks (detailed in para. 6) were found by experience to represent a good and fair day's work for the labour. Fines for non-completion of task were very occasional.

These are the chief points worth noting. Their record in this note will, it is hoped, prove of value when next famine conditions occur, and famine labour is again utilised on a large scale in ravine reclamation work.

VOL. VII PART VIII

THE INDIAN FOREST RECORDS

Afforestation of Ravine Lands in the Etawah District, United Provinces.

By

E. A. SMYTHIES, I.F.S.,
Sylviculturist, United Provinces.

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By

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